Latent Trajectory Groups of Maternal Depressive and Anxiety Symptoms and the Associated Risk Factors

A Thesis Submitted to the
College of Graduate and Postdoctoral Studies
In Partial Fulfillment of the Requirements
For the Degree of Master of Public Health
In the School of Public Health
University of Saskatchewan
Saskatoon, Saskatchewan
Canada

By
Asma Ahmed

May 2017

Permission to Use

In presenting this dissertation in partial fulfillment of the requirements for a graduate degree from the University of Saskatchewan, I agree that the libraries of this university may make it freely available for inspection. I further agree that permission for copying of this dissertation in any manner, in whole or in part, for scholarly purposes may be granted by the professor or professors who supervised my dissertation work, or in their absence, by the head of the department or the dean of the college in which my dissertation work was done. It is understood that any copying or publication or use of this dissertation or parts thereof for financial gain shall not be allowed without my written permission. It is also understood that due recognition shall be given to me and to the University of Saskatchewan in any scholarly use which may be made of any material in my dissertation. Request for permission to copy or to make other use of material in this dissertation in whole or in part should be addressed to:

Department Head
School of Public Health
University of Saskatchewan
104 Clinic Place
Saskatoon, SK S7N 2Z4

Abstract

Background: There is a growing evidence that depression and anxiety disorders have distinct groups of symptom trajectories, which are associated with factors that may vary among different groups. Studying these mental health trajectories is highly relevant during major life transitions, such as pregnancy and childbirth. The aim of this thesis is to identify subgroups of women who exhibit distinct longitudinal trajectory patterns of depressive and anxiety symptoms from early pregnancy to early postpartum and from pregnancy to five years postpartum and the risk factors associated with these trajectories.

Methods: This study uses a longitudinal data collected from 615 women in Saskatchewan, Canada from pregnancy to five years postpartum between 2006 and 2013 (Feelings in Pregnancy and Motherhood (FIP) longitudinal study). The semiparametric group-based modeling strategy was used to identify the latent groups of maternal depressive and anxiety trajectories. Multinomial logit models were then used to explore the association between these latent trajectory groups and various maternal characteristics.

Results: Across pregnancy to early postpartum, we identified four trajectory groups of depressive symptoms: low-stable (49.6%); moderate-stable (42.3%); postpartum (3.6%); and antepartum (4.6%), and three latent trajectory groups of anxiety symptoms: very low-stable (8.9%); low-stable (60.7%); and moderate-stable (30.4%). From pregnancy to five years postpartum, four latent trajectory groups of depressive symptoms were identified: low-stable (35.0%); moderate-stable (54.0%); low-rising (5.2%); and high-declining (5.9%), and three latent trajectory groups for anxiety symptoms were identified: very low-stable (13.0%); low-stable (58.1%); and high-stable (29.0%). Several maternal risk factors, most notably past depression and stress level, were associated with these trajectories.

Conclusion: Distinct latent trajectory patterns of maternal depressive and anxiety symptoms were identified, which were associated with different profiles of risk factors present prior to or during pregnancy. Our findings support the need for multiple assessments starting from early pregnancy to the postpartum, which may help to recognize women at high risk of major depression or anxiety. All significant risk factors can be identified during regular follow-up and thus, clinicians may be able to identify women at high risk, who may be potential candidates for early interventions that may alter the progress of their mental health symptoms.

Acknowledgements

I would like to express my sincere gratitude to my thesis co-supervisors Dr. Cindy Xin Feng and Dr. Angela Bowen for their invaluable time, support, and guidance throughout my journey in completing one of my greatest accomplishments. Their continued mentorship and encouragement during all phases of my master's degree were invaluable.

My special thanks to my thesis committee members: Dr. Nazeem Muhajarine and Dr. Lalita Bharadwaj, for their invaluable support and suggestions. I would like to extend my special thanks to Dr. Angela Bowen and Dr. Nazeem Muhajarine for the opportunity to work on the 'Feelings in Pregnancy and Motherhood' data. I would also like to thank Dr. Haizhen Mou, my external examiner, for her knowledge, expertise and support.

Many thanks to all the faculties, staff, and my fellow students at the School of Public Health of the University of Saskatchewan for supporting me during my study. I would like to especially thank Dr. Suresh Tikoo, Director of thesis-based programs of the School of Public Health for his support and Ms. Marylin Rana, assistant of thesis-based programs for facilitating the committee meeting process throughout the process.

I would also like express my deepest gratitude to my parents, Mohamed and Mariam, who made sure my siblings and I had the education and support we needed to succeed, and even though I am far away, their love and prays continue to give me the strength to proceed.

Lastly, my deepest thanks go to my husband, Hesham, without whom this thesis surely could not have been written. I will never be able to adequately thank him for his support, love, and kindness. I am also very grateful to my two sweet children, Nebras and Jumana, having them around have given me strength and energy, and without them, my journey in graduate school would not be as much fun.

Dedication

This thesis is dedicated to:

My beloved parents, Mohamed and Mariam, the reason of whom I have become today.

My husband and two children, Hesham, Nebras, and Jumana, for their love, support, and for their confidence in me.

Table of Contents

List of Tables

List of Figures

Chapter 1: Introduction

Depression and anxiety are issues of global significance. According to the 2017 World Health Organization (WHO) report, around 4.4% and 3.6% of the world's population are suffering from depression and anxiety respectively (WHO, 2017a). Moreover, depression was ranked by the WHO as the number one contributor to global disability (7.5% of all years lived with disability in 2015), while anxiety was ranked 6th (3.4% of all years lived with disability in 2015) (WHO, 2017a). What is even more disturbing is that global rates of these common mental disorders are on the rise and both disorders are more common in women than men (WHO, 2017a).

The time around a baby's birth is a major period of transition in many women's lives, and as much excitement and joy this experience may bring, there can be many hormonal, psychological, and physical changes taking place, which may leave the woman vulnerable to depression and/or anxiety (Britton, 2008; Onunaku, 2005). Maternal depression is a term that encompasses a spectrum of depressive conditions that can affect women during pregnancy and up to 1 year postpartum, as it includes both antenatal depression and postpartum depression (Santoro & Peabody, 2010). It is diagnosed using the same criteria as major depressive disorders, with the addition of the timing of symptoms during pregnancy and/or within 1 year of giving birth (American Psychiatric Association, 2013). According to the WHO, about 10% of pregnant women and 13% of women during postpartum period has a mental illness, mostly depression (WHO, 2016a). This is even worse in the developing nations with figures of 15.6% during pregnancy and 19.8% during the postpartum period (WHO, 2016a). Major predictors of maternal depression include the presence of depressive or anxiety symptoms during pregnancy, past history of depression, lack of social support, and recent stressful life event (O'Hara & Swain, 1996). Other factors that have been associated with maternal depression include younger age, being unmarried, low-income, low-level of education, smoking, marijuana or illicit drug use, history of abuse, either physical or sexual, intimate partner violence, relationship dissatisfaction, ethnicity, and being unemployed (Golding, 1999; Goyal, Gay, & Lee, 2010; Lancaster et al., 2010; Le Strat, Dubertret, & Le Foll, 2011; O'Hara & Swain, 1996).

Several theorists tried to explain the etiology of maternal depression from multiple perspectives (Beck, 2002). One of these theories is the medical model in which maternal depression is viewed as a medical condition solely determined by some biological factors (Beck, 2002). Several researchers have tried to specify the biological factors responsible for maternal depression but their results remain inconclusive (Westall & Liamputtong, 2011). Hormonal changes around the time of birth have been implicated as the possible biological explanation of maternal depression, which include the dramatic drop of estrogen and progesterone after giving birth, the hyperactivity of the hypothalamic-pituitary-adrenal access, and the changes in the prolactin and oxytocin hormones' levels (Wisner, Parry, & Piontek, 2002). As per this model, women with a history of depression during pregnancy or postpartum may be at increased risk of developing these symptoms again because they are more sensitive to the changes in hormonal levels than women with no history of such an illness (Bloch et al., 2000). Stress can also invoke hormonal changes including increased activity of the HPA axis, and reduced levels of norepinephrine (Anand & Charney, 2000; Oshima et al., 2001). On the other hand, Sichel and Driscoll in their earthquake model believes that the risk of maternal depression "earthquake" is determined by the woman's genetic and hormonal factors and her life experiences (Sichel & Driscoll, 1999). Hence, stressful life events or rapid changes in hormonal levels such as around the time of giving birth can trigger depression (Beck, 2001). This model accounts for a range of risk factors of maternal depression, including personal history of depression, and high stress levels, and hormonal changes (Beck, 2001). The biopsychosocial model attempts to address the social and psychological aspects of maternal mood disorders that are ignored in the biomedical model (Westall & Liamputtong, 2011). History of mental illness fits the biological dimension of the model, whereas psychosocial factors such as socioeconomic status, social support, and relationship with the partner go under the social and psychological dimensions of this model (Westall & Liamputtong, 2011).

Anxiety symptoms during pregnancy or after giving birth are relatively common; up to 24% of pregnant women (Heron et al., 2004), and as high as 18% of women postnatally have anxiety symptoms (Farr, Dietz, O'Hara, Burley, & Ko, 2014). As the literature indicates, major risk factors of maternal anxiety include history of psychiatric problems, medical and negative social life events, high levels of stress, low-education level, low-income, lack of social support, and a history of child abuse (Britton, 2008; Buist, Gotman, & Yonkers, 2011). The presence of

anxiety symptoms during pregnancy is associated with increased risk of postpartum depression (Sutter-Dallay, Giaconne-Marcesche, Glatigny-Dallay, & Vedoux, 2004). Moreover, anxiety symptoms during the perinatal period are often comorbid with depressive symptoms (Farr et al., 2014).

Maternal depression and anxiety are associated with poor health outcomes for the woman and her entire family. Chronic depression affects the woman's long-term health, with increased morbidity (most notably more frequent and severe depressions) as well as physical and cognitive decline (Goveas et al., 2014). Emotional withdrawal and disengagement from normal functions may lead to further breakdown of the woman's primary relationships, threatening her social supports (Seto, Cornelius, Goldschmidt, Morimoto, & Day, 2005), and contribute to a greater risk for postpartum depression. Moreover, left untreated, depression contributes to psychosis and the potential for homicide, infanticide, and suicide (Heron, Haque, Oyebode, Craddock, & Jones, 2009; Spinelli, 2004). Partners of women with postpartum depression are up to 50% more likely to become depressed themselves, especially if the woman is severely depressed (J. H. Goodman, 2004), and employment and health care costs are also negatively impacted (Crown et al., 2002). Maternal mental health is particularly important because of the potential effects on unborn and early child health and development (Cummings & Davies, 1994; Evans et al., 2012; Field et al., 2008; Glover & O'Connor, 2006; J. H. Goodman, 2004; Kahn, Brandt, & Whitaker, 2004; O'Conner, Heron, Glover, & Team, 2002; Rouse & Goodman, 2010; Suri, Altschuler, L, Hellemann, G, Burt, V, K, Aquino, A, & Mintz, J, , 2007). Studies of babies exposed to maternal anxiety and depression in-utero have increased cord and serum cortisol levels and abnormal brain wave activity (Diego et al., 2004). They are more likely to experience prematurity, low birth weight, colic, infant and child mental health problems, and decreased school readiness, decreased cognitive functioning and reasoning, linguistic and drawing abilities, and delayed developmental milestones (Murray & Cooper, 2003; Surkan et al., 2014; Tearne et al., 2015). This combination of factors may indicate dysregulation of the infant's normal physiology, which in the context of maternal mental health will have a further negative effect on mother-baby interaction and attachment (Misri & Kendrick, 2008).

1.1. Purpose of the Study

There is growing evidence that depressive and anxiety symptoms are heterogeneous with their onset, course, duration, and severity (Campbell, Matestic, von Stauffenberg, Mohan, &

Kirchner, 2007; Cents et al., 2013; Giallo, Cooklin, & Nicholson, 2014; Nandi, Beard, & Galea, 2009; van der Waerden et al., 2015). According to Raudenbush (2001), "It makes no sense to assume that everyone is increasing (or decreasing) in depression. .... many persons will never be high in depression, others will always be high, while others will become increasingly depressed" (p. 513). Previous research supports that depression and anxiety disorders do have distinct groups of symptom trajectories, and these trajectories are associated with some factors that may vary between groups (Nandi et al., 2009). Nonetheless, as per Nandi and colleagues, research in this area is still in its infancy. Studying these mental health trajectories is highly relevant during major life transitions, such as pregnancy and childbirth (Skipstein, Janson, Stoolmiller, & Mathiesen, 2010). Such published research is particularly sparse in the perinatal setting, as fewer studies have devoted to clustering the trajectories of depressive or anxiety symptoms and linking the latent classes to demographic, environmental, and psychological and psychosocial factors.

Previous research provides evidence for the existence of longitudinal trajectories of maternal depression and anxiety (Bayrampour, Tomfohr, & Tough, 2016; Campbell et al., 2007; Cents et al., 2013; Skipstein et al., 2010; Sutter-Dallay, Cosnefroy, Glatigny-Dallay, Verdoux, & Rascle, 2012; van der Waerden et al., 2015). However, their findings may depend on the study population and length of follow-up. The experiences of women in the US or Europe may differ from those of women in other parts of the world. Thus, it is of particular significance to study and identify distinct trajectories of maternal depressive symptoms and trajectories of maternal anxiety symptoms within the Canadian context. It is also essential to recognize the socio-demographic, health behaviors, and psychosocial characteristics associated with these groups which will suggest plausible linking to causal pathways. Recognizing the heterogeneity of these common disorders may help identify some modifiable factors that are linked to certain trajectory groups (Nandi et al., 2009). Moreover, identifying these subgroups may help to develop targeted preventative measures such as screening and assessment, as well as treatment interventions.

1.2. Research Questions

We used the longitudinal data from the Feelings in Pregnancy Study and the subsequent Feelings in Pregnancy and Motherhood Study: Child and Maternal Outcomes collected from 615 women in Saskatchewan in 2006-2013 to gain a better understanding of the longitudinal patterns of maternal depression and anxiety and associated antenatal risk factors. We suggest that the period from pregnancy to early postpartum is a unique time for the woman, because of the

hormonal, physiological, and emotional changes, and thus, we chose to analyze the data over two periods of follow-up: early pregnancy to early postpartum and then from early pregnancy to five years postpartum.

This research in this thesis essentially comprises two primary goals: (1) to identify trajectory groups for depressive and anxiety symptoms over the course of pregnancy and early postpartum and over the course of pregnancy to five years postpartum and (2) to investigate what and how are the maternal sociodemographic, psychosocial, and behavioral characteristics associated with identified trajectory groups.

1.3. Organization of the Thesis

This thesis is organized as follows. Chapter 2 presents an extensive review of the literature under three main areas: a) maternal depression, its definition, diagnosis, prevalence, effect on the mother and her family and the economic impact, as well as its risk factors; b) maternal anxiety, its definition, types, prevalence, effect on the mother and her family, as well as its risk factors; and 3) the evidence of trajectories of maternal depression and anxiety across the perinatal period and beyond. Chapter 3 illustrates the materials and methods utilized in this thesis (recruitment, sample, measures, and data analysis), with a focus on the semiparametric group-based modeling approach used in this thesis. Chapter 4 presents a manuscript that focuses on identifying trajectories of perinatal depressive and anxiety symptoms across pregnancy and early postpartum and the associated risk factors. Chapter 5 contains a second manuscript that presents the trajectories of maternal depressive and anxiety symptoms beyond the perinatal period (from pregnancy up to 5 years postpartum) and their antenatal predictors. Finally, in Chapter 6, we discuss the main findings of the thesis, major strengths and limitations, implications for care providers and policy makers, areas of future research, and the conclusion.

1.4. Definitions

- Antenatal/antepartum depression: Major or minor depressive episodes that occur during pregnancy (Santoro & Peabody, 2010).
- Maternal anxiety: Anxiety symptoms during pregnancy and up to one year postpartum, and it includes both antenatal and postnatal anxiety (Leach, Poyser, & Fairweather-Schmidt, 2015).

- Maternal depression: A term that encompasses a spectrum of depressive conditions that can affect women during pregnancy and up to one year postpartum, and it includes both antenatal depression and postpartum depression (Santoro & Peabody, 2010).
- Parity refers to the number of previous pregnancies that continued to a viable gestational age (20 or more weeks) (Cunningham et al., 2009).
- Perinatal period: The period between 22 completed weeks (154 days) of gestation (the time when birth weight is normally 500 g), and the end of seven completed days after birth (WHO, 2017b).
- Postnatal/postpartum depression: Major or minor depressive episodes that occur in the first 12 months after delivery (Santoro & Peabody, 2010).
- Postnatal/postpartum period: the time after giving birth, but usually refers to the period between delivery and six weeks of giving birth.
- Post-term delivery: giving birth after 42 completed weeks or more (294 days or more) of gestation (Galal, Symonds, Murray, Petraglia, & Smith, 2012).
- Prenatal/antenatal period: the time between conception and giving birth.
- Pre-term delivery: giving birth before 37 completed weeks (less than 259 days) of gestation (WHO, 2016b).

Chapter 2: Literature Review

2.1. Maternal Depression

2.1.1 What is maternal depression? Having a baby can be a joyful experience to women, but at the same time, many physical, emotional, and hormonal changes take place that can cause stress, sadness, depression, and moodiness (Onunaku, 2005). Women who face these mixed emotions can feel guilt and shame, and may be unable to openly express their feelings if they differ from the societal expectations of mothers (Onunaku, 2005). While most women will quickly recover from these negative feelings, some women will continue to experience these moods and their symptoms might progress to a level that will negatively impact themselves, as well as their loved ones (Onunaku, 2005).

Antenatal depression. This represents the depressive symptoms that some women experience during pregnancy. During pregnancy, a range of hormonal, physiological, and physical changes take place, which when combined with the stress and demands of pregnancy, as well as other psychosocial factors such as history of depression can result in antenatal depression (Santoro & Peabody, 2010). Women with antenatal depression can experience symptoms like bouts of depressed mood, irritability, moodiness, anxiety, and insomnia, which can also be associated with normal pregnancy (Bowen, Bowen, Balbeuna, & Muhajarine, 2012). Therefore, pregnant women are less likely to identify their symptoms and to seek help or advice (Onunaku, 2005; Santoro & Peabody, 2010).

Postnatal depression. It is a clinical condition characterized by a set of symptoms that meet the criteria of major depression disorders (Santoro & Peabody, 2010). These symptoms can be similar to postpartum blues, but they persist beyond two weeks (Santoro & Peabody, 2010). Symptoms may develop any time within the first 12 months postnatally (usually within the first 2-3 months) (Santoro & Peabody, 2010). Symptoms of postnatal depression may include tearfulness, emotional lability, irritability, fatigue, poor concentration, feelings of guilt, loss of appetite, inability to cope, as well as sleep disturbances (Stewart, Robertson, Dennis, Grace, & Wallington, 2003). Many of these symptoms, such as sleep and appetite changes can be hard to

distinguish from the normal symptoms of "being a mother," especially for first-time mothers (Santoro & Peabody, 2010).

2.1.2. Diagnosis of maternal depression. Several screening tools have been developed to screen women for depression during the perinatal period. One of the most common validated screening tools for the detection of perinatal depression is the Edinburgh Postnatal Depression Scale (EPDS). The EPDS is one of the most commonly validated screening tools for detection of perinatal depression (Cox, Holden, & Sagovsky, 1987), but it is also validated for the screening of antenatal depression (Buist et al., 2002). It is a 10-item self-rated measure that is completed in less than 5 minutes (Cox et al., 1987; The American College of Obstetricians and Gynecologists, 2015). It has a sensitivity of 59–100% and specificity of 49–100% (The American College of Obstetricians and Gynecologists, 2015). The EPDS items are presented in a Likert scale from zero to three with a maximum score is 30. Women with scores higher than 10 (within community settings) and 12 (within research studies) are probably depressed and they need further assessment (Cox et al., 1987).

The American Psychiatric Association: Diagnostic and statistical manual of mental disorders (DSM-5) does not recognize postpartum depression as a separate diagnosis, instead, maternal depression is diagnosed using the same diagnostic criteria that are used to diagnose major depressive disorders, with the addition of onset of symptoms during pregnancy or within four weeks after birth (American Psychiatric Association, 2013).

The DSM-5 criteria for a major depressive episode are as follows:

A. Five or more out of nine symptoms (including at least one of depressed mood and loss of interest or pleasure) in the same two-week period. Each of these symptoms needs to be present nearly every day:
    - Depressed mood (subjective or observed); can be irritable mood in children and adolescents, most of the day;
    - Loss of interest or pleasure, most of the day;
    - Change in weight or appetite. Weight: 5 percent change over 1 month;
    - Insomnia or hypersomnia;
    - Psychomotor retardation or agitation (observed);
    - Loss of energy or fatigue;
    - Worthlessness or guilt;

- Impaired concentration or indecisiveness; or
- Recurrent thoughts of death or suicidal ideation or attempt.

B. Symptoms cause significant distress or impairment.
C. Episode is not attributable to a substance or medical condition
D. There has never been a manic or hypomanic episode. Exclusion d) does not apply if a (hypo)manic episode was substance-induced or attributable to a medical condition.
E. Episode is not better explained by a psychotic disorder (American Psychiatric Association, 2013).

2.1.3. The magnitude of the problem. Maternal depression is an issue of global significance. According to the WHO, about 10% of pregnant women and 13% of women during postpartum period has a mental illness, mostly depression (WHO, 2016a). This is even higher in developing nations with figures of 15.6% during pregnancy and 19.8% during the postpartum period (WHO, 2016a). The Canadian Maternity Experiences Survey (MES) (2006-2007) reported a prevalence rate of postnatal depression of 8.69% (Lanes, Kuk, & Tamim, 2011). The rate varied between provinces, ranging from 5.03% in New Brunswick to 15.09% in Northern Territories (Lanes et al., 2011). These numbers, however, may have underestimated the rates of postnatal depression, as surveys were administered 5-14 months postpartum when some depression symptoms might have dissipated or been treated (Lanes et al., 2011). In Saskatchewan, up to one in five women suffer from depression during the perinatal period, which means that approximately 2,800 Saskatchewanian women are affected annually (Bowen, 2010), and these figures may be substantially higher for women who are considered at social high risk (up to 29.5%) (Bowen, 2010).

2.1.4. Effect on the mother. Maternal depression is associated with increased morbidity and mortality among affected mothers (Bonari et al., 2004). Left untreated, depression contributes to psychosis and the potential for homicide, infanticide, and suicide (Heron et al., 2009; Spinelli, 2004). Emotional withdrawal and disengagement from normal functions may lead to further breakdown of the woman's primary relationships, threatening her social supports (Seto et al., 2005), and contribute to a greater risk for postpartum depression. Moreover, untreated maternal depression is associated with obstetrical and puerperal complications, including gestational hypertension and preeclampsia, spontaneous abortions, bleeding, besides the

increased risk of preterm deliveries and operative deliveries (Bonari et al., 2004; Dayan et al., 2002; Kurki, Hiilesmaa, Raitasalo, Mattila, & Ylikorkala, 2000; Preti et al., 2000).

Women with depression are less likely to take care of themselves during pregnancy, and thus they are less likely to have a good prenatal care, and more vulnerable to negative health behaviors, most notably smoking, alcohol use, and/or recreational drug use during pregnancy (Bonari, Bennett, Einarson, & Koren, 2004; Le Strat et al., 2011). Chronic depression affects long-term health, with increased morbidity (most notably more frequent and severe depressions) as well as physical and cognitive decline (Goveas et al., 2014; Katon, 2003).

2.1.5. Effect on the partner. Maternal depression also has a negative effect on the woman's partner. Up to 50% of partners of women with perinatal depression also develop depressive symptoms, which may have serious implications on the family's health and well-being (J. H. Goodman, 2004). This would further escalate the negative impact maternal depression on the infant's development (Kahn et al., 2004). Marital problems or even breakdown have also been linked to maternal depression (Doheny, 2008).

2.1.6. Economic effect. There is a huge economic burden associated with maternal depression. This can partly be attributed to the reduced productivity of partners either because of the time they spent caring for the depressed mother and their children, or due to stress, marital problems, or depression (WHO, 2013). Other contributing factors include the adverse effect of depression on concentration, decision-making skills, and sleep of working pregnant women or women returning early to work after birth, which in turn negatively affect their productivity of (O'Brien, Laporte, & Koren, 2009). There is also a direct cost to the health care system due to above-average physician visits and hospitalizations (O'Brien et al., 2009). In Ontario, the estimated annual healthcare cost due to untreated maternal depression in pregnancy is $20.5 million (O'Brien et al., 2009). When this data is adjusted for Saskatchewan's birth rates, over $2 million dollars are spent annually on costs related to untreated depression during pregnancy (Bowen, 2010). The real cost of maternal depression would be substantially higher than these numbers if postpartum depression was considered (Bowen, 2010). Other costs are related to the increased risk of preterm births and low birth weight infants, which adds a substantial cost to the health system (O'Brien et al., 2009). The long-term impact of maternal depression on child development (such as developmental delays and behavioral problems) would also increase the

burden on the education system, social services, along with the health care system (Bowen, 2010).

2.1.8. Effect on children. Maternal depression does not only affect the mother, but also her children. However, the relationship between maternal depression and children's outcomes is not simple, as the variability of the maternal depressive symptoms in terms of onset, duration, and severity, and the presence of co-morbidity, beside the socioeconomic, demographic, and environmental factors may also play an important role in shaping the effect of maternal depression on children outcomes (Cummings & Davies, 1994).

Antenatal depression is associated with several negative neonatal outcomes, including increased distress after delivery, impairment in their orientation and motor activities, and sleep disturbances (Suri, Lin, Cohen, & Altshuler, 2014). Long-term impacts include depression and behavioral problems (Suri et al., 2014). Moreover, depressive symptoms during pregnancy negatively affect children's cognition, likely due to high maternal cortisol levels, with the subsequent rise in fetal cortisol that can affect fetal neurodevelopment (Evans et al., 2012).

Postnatal depression affects multiple aspects of children's development and increases their susceptibility to the later development of mood disorders (Rouse & Goodman, 2010), and these effects get worse as the maternal depression lasts longer (Evans et al., 2012). Depressed mothers are unresponsive to their infants, they have flat affection, and are less supportive to the infant (Cummings & Davies, 1994). Consequently, infants may develop passivity, are less securely attached, be withdrawn, and might self-regulate themselves through measures like thumb sucking (Cummings & Davies, 1994). Toddlers and preschoolers whose mothers suffer from depression are more likely to have poor self-control, problems with social interactions, and are more likely to have internalizing and externalizing problems (Cummings & Davies, 1994). Other effects include a higher risk of affective disorders, such as depression, anxiety disorders, conduct disorders, higher risk of antisocial behaviors, attention deficit hyperactivity disorder, lower IQ scores, attention difficulties, and the need for special education (Cummings & Davies, 1994; Murray, Hipwell, Hooper, Stein, & Cooper, 1996).

2.1.9. Risk factors for maternal depression.

Sociodemographic factors.

a- Age: Several research studies have identified age as a risk factor for maternal depression, and the younger the age of the woman, the higher her risk is of developing maternal

depression (McCue Horwitz, Briggs-Gowan, Storfer-Isser, & Carter, 2007; Nakku, Nakasi, & Mirembe, 2006; Wang, Wu, Anderson, & Florence, 2011). Wang and colleagues used data from the National Institute of Child Health and Human Development (NICHD) Study of Early Child Care and Youth Development to examine the prevalence and risk factors of maternal depression over the first three years postpartum. They found that young maternal age significantly predicted early onset (within the first six months postpartum) and chronic maternal depression (Wang et al., 2011).

b- Marital status: Marital status has been identified in the literature as a significant risk factor for maternal depression (Wang et al., 2011). The prevalence of depression among single mothers is two to three times the rate in the general population (Wang, 2004). Married women seem to be at the lowest risk of developing maternal depression, compared to women of other marital statuses (being widowed, divorced, separated, or never married) (Le Strat et al., 2011). Beck's meta-analysis of postpartum depression predictors also concluded a moderate relationship between marital status and postnatal depression (Beck, 2001).

c- Ethnicity: There is evidence from the literature that ethnicity affects the risk of developing maternal depression (Bowen, Stewart, Baetz, & Muhajarine, 2009; Ganann, Sword, Black, & Carpio, 2012; Roy, 2014). It has been documented that being an immigrant woman is associated with increased risk of maternal depression (Ganann et al., 2012). Also, women of Indigenous descent may be at increased risk of maternal depression. A study conducted in Saskatchewan, Canada showed that Aboriginal women had higher rates of antenatal depressive symptoms, relative to other Canadian women (Bowen et al., 2009). Historical trauma, unresolved grief, combined with contemporary experiences of racism and sexism are all important factors that may determine mental health outcomes of Aboriginal women (Roy, 2014).

d- Education: Lancaster and colleagues concluded education level as a significant risk factor for antenatal depression (Lancaster et al., 2010). McCue Horwitz (2007) examined the correlates of postpartum depression among 1,053 women in the US and reports that women with less than high school education were more than four times as likely to have persistent maternal depressive symptoms after one year of giving birth as women with high school or beyond education (McCue Horwitz et al., 2007). Another meta-analysis conducted by Robertson and colleagues also found that educational level had a small but significant effect on the risk of developing postnatal depression (Robertson, Grace, Wallington, & Stewart, 2004).

e-Employment: In a Swedish longitudinal study of 2,430 women, unemployment was associated with increased risk of depressive symptoms at multiple points during the perinatal period (Rubertsson, Wickberg, Gustavsson, & Radestad, 2005), similar to what was reported in other studies (Rubertsson, Waldenström, & Wickberg, 2003; Rubertsson, WaldenstrÖm, Wickberg, Rådestad, & Hildingsson, 2005; Wang et al., 2011). A meta-analysis by Robertson and colleagues also concluded that employment status has a small but significant effect on a woman's risk of postnatal depression (Robertson et al., 2004).

f- Income: According to meta-analyses by O'Hara and Robertson, low socioeconomic status poses a significant risk for the development of postnatal depression. Financially disadvantaged women are at high risk of developing maternal depression, as their socioeconomic status may raise their stress levels, and thus increase their vulnerability to develop maternal depression (O'Hara & Swain, 1996; Robertson et al., 2004). Likewise, other researchers found a similar relationship between income and depression during pregnancy and postpartum (Mayberry, Horowitz, & Declercq, 2007; Tiedje, 2009).

g- Parity: Parity refers to the number of previous pregnancies that continued to a viable gestational age (20 or more weeks) (Cunningham et al., 2009). High parity is associated with increased risk of maternal depression (Gürel & Gürel, 2000; Mayberry et al., 2007). In a cross-sectional sample of 1,359 American women, Mayberry et al., (2007) found that high parity is positively correlated with the severity of depressive symptoms. Nonetheless, O'Hara and Swain concluded that results of previous research are inconsistent in regard to the effect of parity on the risk of postnatal depression (O'Hara & Swain, 1996).

Psychosocial factors.

a- Social support: Several studies have linked the lack of social support with increased risk of postnatal depression (Leigh & Milgrom, 2008; McCue Horwitz, Briggs-Gowan, Storfer-Isser, & Carter, 2009). Leigh and Milgrom (2008) examined correlates of antenatal depression among 367 women in Australia and found that women with low level of social support were more likely to experience depressive symptoms during pregnancy., McCue Horwitz et al., (2009) showed that low level of emotional support predicted the persistence of depressive symptoms among 884 mothers of young children in the US. Lancaster and colleagues in their systematic analysis of predictors of antenatal depression identified a moderate relationship between social support and antenatal depression (Lancaster et al., 2010). Similarly, O'Hara and Swain in their

meta-analysis of risk factors of postnatal depression found that both overall social support, as well as support from the baby's father during pregnancy had a powerful effect on the risk of postnatal depression (O'Hara & Swain, 1996).

b- Stress: There is evidence from the literature that high stress is associated with increased risk of maternal depression (Centers for Disease Control Prevention, 2008; Leigh & Milgrom, 2008; Manuel, Martinson, Bledsoe-Mansori, & Bellamy, 2012). Stress related to parenting, economic difficulty, childcare and poor health increases the risk of maternal depression (Manuel et al., 2012). A report from the Centers for Disease Control and Prevention (CDC) examined the prevalence and risk factors of postnatal depression symptoms in 17 states in the US and reported that financial, emotional, partner-related, and traumatic stressors during pregnancy increase the woman's risk of developing postnatal depression (Centers for Disease Control Prevention, 2008). Support from partner or instrumental support may partially relieve the effect of these stressors on a woman's mental health (Manuel et al., 2012).

c- Unplanned pregnancy: The is some evidence in the literature that unplanned pregnancy may increase the risk of maternal depression (Beck, 2001; McLennan, Kotelchuck, & Cho, 2001). In the study by McLennan and colleagues, 7,537 mothers of toddlers were assessed twice, and they found that unplanned pregnancy was associated with increased risk of depression (McLennan et al., 2001). Likewise, in Beck's meta-analysis, unplanned or unwanted pregnancy was found to pose a small, but significant risk of developing postnatal depression (Beck, 2001).

d- Satisfaction with the relationship: Quality of the relationship with the partner has been shown as a significant predictor of maternal depression (McCue Horwitz et al., 2007). McCue Horwitz et al., (2007) examined correlates of postpartum depression among 1053 women in the US and found that among the 860 women with a partner in their sample, poor quality of the relationship with the partner was associated with elevated depressive symptoms in the early postpartum period. Lancaster and colleagues found that poor relationship quality with the partner is associated with a greater likelihood of antenatal depression (Lancaster et al., 2010). Similarly, O'Hara and Swain concluded that relationship dissatisfaction has a significant effect on the risk of developing postnatal depression (O'Hara & Swain, 1996).

e- Personal history of depression: There is a strong evidence that history of depression significantly increases the risk of developing maternal depression (Beck, 2001; Bernazzani, Saucier, David, & Borgeat, 1997; Leigh & Milgrom, 2008; O'Hara & Swain, 1996). O'Hara and

Swain found a strong association between antenatal depression and the subsequent postnatal depression (O'Hara & Swain, 1996). Moreover, they concluded past personal psychiatric illnesses as one of the strongest risk factors for developing postnatal depression (O'Hara & Swain, 1996). Lancaster and colleagues also concluded that personal history of depression significantly increases the risk of antepartum depression (Lancaster et al., 2010).

Behavioral factors. Tobacco, alcohol, and drug use during pregnancy have many negative effects on the unborn baby (Rivkin et al., 2008; Thompson, Levitt, & Stanwood, 2009). Although the rates of substance use decreases substantially during pregnancy (Vesga-Lopez et al., 2008), some women continue to use them. Le Strat and colleagues examined a cross-sectional data from 1,524 pregnant and postpartum women in the USA and found that using substances (including alcohol, illicit drugs, and cigarettes) is associated with maternal depression (Le Strat et al., 2011). There is some evidence that exercise may affect the risk of depression in pregnancy and the postpartum period (Rahman, Bowen, & Muhajarine, 2014; Strøm, Mortensen, Halldorson, Osterdal, & Olsen, 2009) and lack of exercise during pregnancy has been linked to higher rate of depressive symptoms (Ersek & Brunner Huber, 2009).

2.2. Maternal Anxiety

Anxiety is a common problem in women; with approximately one third of women experiencing anxiety symptoms during their lifetime (Kessler et al., 1994). The average age of onset of anxiety is the mid-20s (Kessler, McGonagle, Swartz, Blazer, & Nelson, 1993), which coincides with childbearing. The perinatal period may be a stressful time for the woman, perhaps with multiple sources of stress and changes over a short period, such as the baby delivery and the new parenting responsibilities, increasing the risk for anxiety during the perinatal period (Britton, 2008).

2.2.1. Types of anxiety disorders Anxiety disorders during pregnancy and/or postpartum may exist in various forms, which include:

1- Generalized anxiety disorder Generalized anxiety disorder is characterized by frequent worry, poor concentration, muscle tension, and fatigue that last for at least six months (American Psychiatric Association, 2013). It can sometimes be challenging to distinguish between generalized anxiety disorder from non-pathologic anxiety, especially around the time of birth when the woman may worry about delivery and/or baby's health (Ross & McClean, 2006). Another common differential diagnosis of generalized anxiety disorder, especially during the

perinatal period, is adjustment disorders with anxiety symptoms, which usually present as anxiety symptoms triggered by a defined stressor (e.g., pregnancy or giving birth) and last for less than six months (Ross & McClean, 2006).

Previous studies have found that the first and third trimesters seem to pose the highest risk of anxiety for perinatal women (Buist, Gotman, & Yonkers, 2011). Buist and colleagues examined generalized anxiety disorders during pregnancy, and they found that 9.5% of women suffer from generalized anxiety disorder during pregnancy, and women are most vulnerable during the first trimester of pregnancy (Buist et al., 2011). Another report found that the rate of generalized anxiety disorder during pregnancy is almost two times higher than the rate during the postpartum period (29.2% and 16.5% respectively) (Andersson, Sundström-Poromaa, Wulff, Åström, & Bixo, 2006). These rates are considerably higher than rates of anxiety in women in the general population who have a one-year prevalence of generalized anxiety disorder of 3% and a lifetime prevalence rate of 5% (Buist et al., 2011).

2- Panic disorder. People with panic disorder suffer from recurrent panic attacks that are of sudden onset, and patients experience persistent stress and worries about having another panic attack. Panic attacks are typically characterized by shortness of breath, palpitation, chest pain, dizziness, feeling of losing control, and fear of dying (American Psychiatric Association, 2013). Women during the perinatal period may interpret their symptoms as a sign that there is something wrong with their baby, and they may isolate their children for fear of having a panic attack in public (Ross & McClean, 2006). As per Ross and McClean, the perinatal period has no effect on the severity of panic disorders, as the prevalence of panic disorders among women during the perinatal period is around 1.3-2%, which is comparable to the prevalence in the general population (Ross & McClean, 2006). Though, there is some evidence that weaning from breastfeeding may exacerbate panic disorders (Ross & McClean, 2006).

3- Obsessive-compulsive disorder. People with obsessive-compulsive disorder experience recurrent intrusive thought or images (obsessions) that provoke anxiety. To relieve anxiety triggered by obsessions, individuals usually engage in repetitive behaviors or thought pattern (compulsions) (American Psychiatric Association, 2013). Obsessive-compulsive disorder during the perinatal period often involve obsessions about harming the baby, which may impact the mother-infant relationship (Ross & McClean, 2006). One systematic review found that obsessive-compulsive disorder is often associated with comorbid depression, and may be linked to pre-term

delivery, post-term delivery, and cesarean birth, although these results are not consistent and they also concluded that there is no clear evidence that the perinatal period is associated with exacerbation of existing obsessive-compulsive disorder (Ross & McClean, 2006).

4- Post-traumatic stress disorder. Post-traumatic stress disorder is characterized by re-experiencing a past traumatic event that involved actual or threatened death or injury of oneself or others, in the form of recollections or recurrent dreams, emotional numbness, avoidance to situations that are associated with the trauma, and/or hyperarousal (American Psychiatric Association, 2013). There is some evidence that post-traumatic stress disorder may occur as a result of childbirth, especially if it involved severe pain or stress (Mayou & Smith, 1997). Presentation of post-traumatic stress disorder during the perinatal period may include dysfunctional mother-infant relationship, sexual dysfunction, and avoidance of future childbirth or requesting cesarean section; however, little is known about new onset perinatal post-traumatic stress disorder or the effect of the perinatal period on symptoms of pre-existing post-traumatic stress disorder (Ross & McClean, 2006).

5- Social phobia and specific phobias A person with a phobia will experience irrational, persistent fear of an object, situation, or thing, that is clearly excessive to the real threat or danger posed by that object or situation (American Psychiatric Association, 2013). Social phobia is a separate disorder that is characterized by excessive fear of social situations (American Psychiatric Association, 2013). Van Veen and colleagues have retrospectively examined the course of social phobia across pregnancy and the postpartum period in 41 women in Netherlands (Van Veen, Jonker, Van Vliet, & Zitman, 2009). They found that most women who had social phobias did not experience any change in their symptoms during the perinatal period (Van Veen et al., 2009). In the subgroup of women who experienced social phobia in pregnancy and postpartum, they found that their symptoms were lower during pregnancy than before pregnancy or postpartum (Van Veen et al., 2009).

2.2.2. The magnitude of the problem. Anxiety disorders during pregnancy and/or postpartum period have received little attention in the literature. Nonetheless, several research studies concluded that women are at higher risk of anxiety disorders during the perinatal period than other times of the woman's life (Buist et al., 2011; Figueiredo & Conde, 2011; Roos, Faure, Lochner, Vythilingum, & Stein, 2013). Several studies concluded that the severity of anxiety symptoms decrease during postpartum (Agrati et al., 2015; Figueiredo & Conde, 2011; Madigan

et al., 2014). The reduction of anxiety symptoms after giving birth could be attributed to the interaction between the mother and her baby, especially breastfeeding, likely due to hormonal changes and/or physical contact with the baby (Agrati et al., 2015; Jonas, Nissen, Ransjö-Arvidson, Matthiesen, & Uvnäs-Moberg, 2008; Macbeth & Luine, 2010).

Anxiety disorders during pregnancy are often associated with comorbid conditions, mostly depression, or the concurrence of multiple types of anxiety disorders at the same time (J. H. Goodman, Chenausky, & Freeman, 2014). As Goodman and colleagues' systematic review examining anxiety disorders during pregnancy reveals the prevalence of antenatal anxiety varies significantly for all anxiety disorders and for specific anxiety disorders (J. H. Goodman et al., 2014). The reported prevalence rates of all anxiety disorders ranged from 4.4 to 39%, whereas the prevalence rates per type of anxiety disorders were 0%–10.5% for generalized anxiety disorders, 0.2%–5.7% for panic disorder, 0%–5.2% for obsessive-compulsive disorders, 3.2%–19.9% for specific phobia, 0.4%–6.4% for social phobia, 0.9% for agoraphobia without history of panic, 17.2% for any agoraphobia, and 0%–7.9% for posttraumatic stress disorders (J. H. Goodman et al., 2014).

A study by Wenzel et al., examined the prevalence of anxiety disorders in 147 women at eight weeks after giving birth. They concluded that generalized anxiety disorders were more common in postpartum women than in women representative of the general population, whereas prevalence rates of other types of anxiety were either as common or less common than those of women in the general population (Wenzel, Haugen, Jackson, & Brendle, 2005). In addition, between 40 and 50% of the women with anxiety and/or depressive symptoms had a postpartum onset of their symptoms, and comorbid depressive symptoms were particularly common in individuals with generalized anxiety symptoms (around 50%) (Wenzel et al., 2005).

2.2.3. The effects of maternal anxiety. The presence of anxiety symptoms during pregnancy and/or postpartum can negatively impact the health outcomes of the mother and her offspring (Buist et al., 2011; Heron et al., 2004; O'Conner et al., 2002). Antenatal anxiety significantly increases the risk of postnatal depression (Buist et al., 2011; Sutter-Dallay el al., 2004). Heron and colleagues found that antenatal anxiety predicts postnatal depression at eight weeks and eight months postpartum (after controlling for antenatal depression) (Heron et al., 2004). Moreover, anxiety in the first few days after birth is linked to postnatal depression (Teissedre & Chabol, 2003). Maternal anxiety is also associated with obstetric complications

(Alder, Fink, Bitzer, Hösli & Holzgreve, 2007; (Lilliecreutz, Sydsjö, & Josefsson, 2011); for example women with blood/injection phobia had higher rates of elective cesarean section, preterm delivery, preeclampsia, higher neonatal morbidity, their babies were more often small for gestational age, and had a longer postpartum hospital stay (Lilliecreutz et al., 2011).

Strong evidence exists about the negative impact maternal anxiety on children's development (Feldman et al., 2009; Heron et al., 2004; O'Donnell et al., 2013). In animal studies, antenatal anxiety was found to cause many disturbances in the offspring when they reach adulthood (Schneider & Moore, 2000). Human studies also report that antenatal anxiety causes physical defects in children (Hansen, Lou, & Olsen, 2000), low birth weight (Hedegaard, Henriksen, Sabroe, & Secher, 1993), behavioral and emotional problems among offspring (O'Conner et al., 2002), and is linked to fetal activities and development (DiPietro, Hilton, Hawkins, Costigan, & Pressman, 2002). Maternal anxiety is linked to various negative effects on the fetal central nervous system development (O'Conner et al., 2002), which could be explained by the hyper-activity of the mother's neuroendocrine system (Ross & McClean, 2006). Grant et al. (2009), examined infants' responses to mild stressors at the age of seven months and found that infants of mothers who suffered from antenatal anxiety had significantly higher cortisol levels in response to these stressors, but with no significant difference in their behavioral responses (Grant et al., 2009). Another report found that infants of mothers with antenatal anxiety had decreased P50 sensory gating—a possible marker for early attentional processes in infants (Hunter et al., 2012). Postnatal anxiety is associated with decreased efficacy in parenting role (Porter & Hsu, 2003), reduced coping abilities, reduced maternal sensitivity, late psychosocial pathologies in the mother, and maladaptation of the child (Barnett, Schaafsma, Guzman, & Parker, 1991).

2.2.4. Risk factors of maternal anxiety disorders. Anxiety symptoms in perinatal women are determined by multiple factors; however, a limited number of studies have looked at risk factors for any anxiety disorder, and only a limited number of potential risk factors have been examined (marital status, SES, and parity) with inconsistent findings (J. H. Goodman et al., 2014). As perinatal anxiety often coexists with depression, risk factors for both conditions may be similar (Buist et al., 2011). Britton (2008) looked at predictors of early postnatal anxiety (one month postpartum) among 269 women and found that history of psychiatric problems including depressed mood, medical and negative social life events, lack of pregnancy planning and prenatal

class attendance, perceived perinatal stress, and the duration of postpartum hospital stay were positive correlates of early postpartum anxiety, whereas education, household income, and resiliency factors were inverse correlates (Britton, 2008). Another report examined risk factors for generalized anxiety disorders during pregnancy among 2,793 women found that a history of generalized anxiety disorder, education, social support and a history of child abuse are associated with generalized anxiety disorders during pregnancy (Buist et al., 2011). Predictors of post-traumatic stress disorder include trauma or child abuse, current depression, current panic disorder, current suicidality, sexual assault, and serious physical attack or assault (J. H. Goodman et al., 2014). In regard to obsessive-compulsive disorder, positive family history of obsessive compulsive disorder seems to be the major risk factor (J. H. Goodman et al., 2014).

2.3. Course of Maternal Depression and Anxiety over Time

The literature suggests that maternal depressive and anxiety symptoms are heterogeneous with their symptom syndromes and trajectories, and their trajectories may be determined by risk factors specific to each subtype (Bayrampour et al., 2016; Campbell et al., 2007; Nandi et al., 2009; Sutter-Dallay et al., 2012; van der Waerden et al., 2015). The trajectories of maternal depression differ among populations and over a varying amount of time, and studies mostly identify between four to six trajectory groups (Campbell et al., 2007; Cents et al., 2013; Luoma, Korhonen, Salmelin, Helminen, & Tamminen, 2015; Skipstein et al., 2010; Sutter-Dallay et al., 2012; van der Waerden et al., 2015). Mora and colleagues followed low-income, inner-city residents in the US from pregnancy to two years postpartum for depressive symptoms as measured by Center for Epidemiologic Studies Depression (CES-D) Scale and identified five depression trajectory classes: never depressed (the largest class), antepartum only, postpartum, late postpartum, and chronic class (Mora et al., 2009). Another study of low-risk women in France that also used the CES-D screening tool identified four trajectories of maternal depressive symptoms from pregnancy to two years postpartum somewhat like those Mora and colleagues identified; never depressed, postnatal, chronic persistent, and chronic with exacerbation during pregnancy (Sutter-Dallay et al., 2012). Despite the socioeconomic differences between the two study populations, 70% of the women belonged to the never depressed group (Mora et al., 2009; Sutter-Dallay et al., 2012). This implies that regardless of income and socioeconomic status, about three-quarters of women are unlikely to exhibit perinatal depressive symptoms (Sutter-Dallay et al., 2012). Likewise, a Finnish study conducted by Vänskä et al. (2011), looked at

mental health trajectories from early pregnancy to one year postpartum. They identified five latent classes of maternal mental health symptoms, with the majority of women (75%) having no symptoms, and the other four classes were antepartum (6%), early postpartum (9%), late postpartum (6%), and high-level symptoms' class (4%) (Vänskä et al., 2011).

Among studies conducted in European countries, Cents and colleagues assessed 4,167 women in the Netherlands for depressive symptoms using the Brief Symptom Inventory from pregnancy to three years postpartum and identified four depression trajectories; 34% of women had no symptoms, 54% had low symptoms, 11% had moderate symptoms, and 1.5% had high symptoms (Cents et al., 2013). French researchers evaluated 1,807 women for depressive symptoms using the CES-D scale from pregnancy to five years postpartum and identified five depression trajectories, and about 60% had no symptoms (van der Waerden et al., 2015). Both studies identified a moderate symptom group and a chronic high symptom group and van der Waerden et al. (2015), further identified a small group with high symptoms only during pregnancy, and another small group with symptoms only between the third and fifth year postpartum.

Two European studies followed mothers for longer periods. Luoma et al., (2015) followed 329 women in Finland for depression measured by the EPDS scale from pregnancy to the 17th birthday of the index child, whereas Skipstein (2010) and colleagues assessed 951 Norwegian women for depressive and anxiety symptoms as measured by the Hopkins Symptom Check List from 18 months to 14.5 years of giving birth. Both studies identified groups with low symptoms, moderate symptoms (Skipstein et al. (2010), divided this trajectory into two classes), high symptoms, and a small group with a fluctuating pattern of symptoms over time put (Luoma et al., 2015; Skipstein et al., 2010). Skipstein et al. (2010), also concluded a small group of women with no symptoms. Nonetheless, both studies used different methodologies to identify these groups, as Luoma used group-based modeling whereas Skipstein used latent profile analysis. A US study by Campbell et al., (2007) assessed 1,261 women for depressive symptoms using the CES-D scale from one month to seven years postpartum and identified six trajectory groups of maternal depressive symptoms, high chronic, moderate increasing, high decreasing, intermittent, moderate stable, and low stable (Campbell et al., 2007).

Although maternal depression is often comorbid with anxiety (S. H. Goodman, 2007; Merikangas, Lieb, Wittchen, & Avenevoli, 2003), maternal depression and anxiety symptoms are

two separate entities as to their clinical presentation and course (Hranov, 2007; Nandi et al., 2009). Anxiety disorders are highly prevalent among the general population (Kessler et al., 1994), but little is known about perinatal anxiety symptoms, and research on maternal anxiety trajectories is particularly scarce. Few studies have looked at the course of anxiety symptoms in pregnancy and/or postpartum and the results are conflicting (Buist et al., 2011). Agrati and colleagues identified two anxiety trajectories from pregnancy to two years postnatally, a U-shaped pattern and a stable linear pattern of anxiety symptoms (Agrati et al., 2015). All women in their sample experienced a decline in their symptoms postpartum, an observation that is consistent with other researchers (Figueiredo & Conde, 2011; Madigan et al., 2014). Though, they observed a rise in anxiety symptoms during the second year of giving birth, which they linked to the increased stress as the child transition from infancy to childhood (Agrati et al., 2015). On the other hand, Don and colleagues found two trajectories of anxiety symptoms from pregnancy to nine months postpartum among first-time parents, moderate stable and low declining (89.4%) (Don, Chong, Biehle, Gordon, & Mickelson, 2014).

Two studies that examined trajectories of both maternal depression and anxiety were conducted in Canada and Taiwan (Bayrampour et al., 2016; Kuo, Chen, & Tzeng, 2014). In a Canadian study, Bayrampour and colleague identified five trajectories for depression and anxiety symptoms from pregnancy to one year postpartum, namely minimal, mild, antepartum, postpartum, and chronic (Bayrampour et al., 2016). The majority of women belonged to either the minimal or mild trajectory groups of depression and anxiety, whereas very small percentages belonged to the chronic groups (Bayrampour et al., 2016). Similarly, Kuo's group in Taiwan identified three depressive trajectories (low, mild, and high) and four anxiety trajectories (low, mild, high, and very high) (Kuo et al., 2014). These trajectories were stable throughout the period of follow-up, probably because of the smaller sample size, and the shorter time of follow-up (late pregnancy to six months postpartum) compared to other studies (Kuo et al., 2014). They also found that depression trajectories were significantly moderately associated with anxiety trajectories (Kuo et al., 2014).

A large body of literature has examined the socio-demographic correlates of maternal depression and anxiety (Beck, 2001; Britton, 2008; Lancaster et al., 2010; McCue Horwitz et al., 2007; O'Hara & Swain, 1996; Robertson et al., 2004; Wang et al., 2011). However, there is a paucity of research that links longitudinal trajectories of maternal depression and anxiety to

socio-demographic and psychosocial predictors. This is particularly important as some risk factors may be associated with only certain subgroups of women with maternal depression or anxiety, which would allow for targeted assessments and interventions. As the literature reveals, major sociodemographic predictors of trajectories with persistent or high maternal depressive and/or anxiety symptoms include young age, low education, low income, and being in an unstable relationship, whereas main psychosocial predictors include high levels of stress, low social support, and past psychiatric illness (Bayrampour et al., 2016; Campbell et al., 2007; Cents et al., 2013; Luoma et al., 2015; Skipstein et al., 2010; Sutter-Dallay et al., 2012; van der Waerden et al., 2015). Appendix A provides details of previous studies that have examined maternal depressive and anxiety trajectories and the associated maternal characteristics.

Chapter 3: Methodology

3.1. Sample

This study is a secondary analysis of data from the Canadian Institute of Health Research funded Feelings in Pregnancy and Motherhood Study (FIP) (CIHR #145179), and the subsequent Feelings in Pregnancy and Motherhood Study: Child and Maternal Outcomes (CIHR-RPP #220896) (A. Bowen, Bowen, Butt, Rahman, & Muhajarine, 2012; Rahman et al., 2014). FIP is a longitudinal epidemiological study of maternal depression and the associated factors over a five-year period between 2006 and 2013. Six hundred and forty-six women in their early pregnancy were recruited from the community using posters at doctors' offices, child care centers, recreational centers, hospitals, prenatal and postnatal classes, maternity stores, newspapers and radio ads, community events, and word of mouth. Women were eligible to participate in the study if they were: 1. within the first 20 weeks of pregnancy, 2. able to speak English, and 3. residing in one of two regional health authorities in Saskatchewan (Saskatoon Health Region and Five Hills Health Region). Data was collected via face-to-face individual interviews by trained research assistants from pregnancy up to five years of giving birth. Women were assessed twice during pregnancy; early (at 17.4 +/- 4.9 weeks of gestation), and late (at 30.6 +/- 2.7weeks of gestation); one time at early postpartum (at 4.2 +/-2.1 weeks postpartum); and at the child's third and fifth birthdays. Among those 646 participants, 31 participants had more than 3 missing values of the outcome variable, and therefore were excluded from the analysis. Hence, our study sample included 615 women who have completed at least two assessments. For using the data in our study, we obtained an ethical approval from the office of research Ethics at the University of Saskatchewan.

3.2. Measures

3.2.1. Maternal depressive symptoms. Depressive symptoms were assessed using the Edinburgh Postnatal Depression Scale (EPDS) (Cox et al., 1987). The EPDS is one of the most commonly validated screening tools for detection of perinatal depression (Cox et al., 1987), but it is also validated for the screening of antenatal depression (Buist et al., 2002). It is a 10-item self-rated measure that is completed in less than five minutes (Cox et al., 1987). It has a sensitivity of

59–100% and specificity of 49–100% (The American College Of Obstetricians & Gynecologists, 2015). It includes questions about anxiety symptoms, but it does not include any questions about the constitutional symptoms associated with depression, such as changes in sleeping habits, and fatigue, which often overlap with common symptoms of pregnancy (Cox & Holden, 2003).The EPDS items are presented on a Likert scale from zero to three with a maximum score is 30. Women with scores higher than 10 (within community settings) and 12 (within research studies) are probably depressed and women need further assessment (Cox et al., 1987).

3.2.2. Maternal anxiety symptoms. The EPDS contains a three-item anxiety subscale (EDPS-A), which consists of item 3 ‘‘I have blamed myself unnecessarily when things went wrong’’), item 4 (‘‘I have been anxious or worried for no good reason’’), and item 5 (‘‘I have felt scared or panicky for no very good reason’’) was used to screen for anxiety symptoms. It was found to be useful as a screening tool for anxiety symptoms during the perinatal period (Matthey, Fisher, & Rowe, 2013). Bowen et al. (2008), confirmed an EPDS anxiety subscale (Items 3–5) during pregnancy (Bowen, Bowen, Maslany, & Muhajarine, 2008), while Ross et al. (2003), confirmed the same factors in postpartum women (Ross, Evans, Sellers, & Romach, 2003). Responses to these three items are reported on a Likert scale from zero to three with a maximum scale is nine. The cut-off that has been used in the literature is five or more (Matthey, Valenti, Souter, & Ross-Hamid, 2013).

3.2.3. Sociodemographic factors.

- Age: participants reported their age in years at the first interview. For this thesis, this variable was categorized as either <25 years or $\geq$ 25 years old.
- Marital status: women were asked about their marital status. Responses to this question were single, common law, married, separated/divorced, and widowed. Women were categorized as partnered (married or cohabiting) or non-partnered (single, widowed, or divorced).
- Ethnicity: women were asked about their ethnicity. Responses were Caucasian, treaty Indian, non-status Indian, Metis, immigrant, and other. The ethnicity of participants was categorized as Caucasian or non-Caucasian.
- Education: respondents were asked about the highest grade or year of school they have completed. Responses were completed grade 8 or less, grade 9-11, completed grade 12, some post-secondary/university, and university/post-secondary graduate. Participants’ educational level variable was dichotomized as below grade 12 and grade 12 or higher.

- Employment: women were asked about their employment status, and their responses were either yes or no.
- Income: women were asked about their family income. The four levels of this variable were social assistance or less than $20,000 per year, between $20,000 and $40,000 per year, between 40,000 and 60,000 per year, and greater than $60,000 per year.
- Parity: Women were asked about the total number of pregnancies, previous abortions and/or miscarriages, and about previous preterm and/or full term deliveries. Parity variable was derived by calculating the number of previous pregnancies that continued to a viable gestational age and it was used as a dichotomous variable with two levels: "0" and "$\geq$1".

3.2.4. Psychosocial factors.

- Social support: social support was measured by asking participants, "Do you have someone to turn to for emotional support?" If they responded yes, they were asked to indicate people who provide them with social support. Responses to these questions were combined into one variable that indicates the level of social support, which has two levels: low-level of support (0-1 support) and high-level of support (two or more sources of support).
- Stress: participants were asked to indicate sources of stress from a list of stressors, including work, place of living, relationship with the partner, being pregnant, the health of the baby, the birth of the baby, school, own health, and other stressors. Their responses were combined into one variable that indicates the level of stress each participant experienced as low stress level (0-2 stressors) or high stress level (more than two stressors).
- Planned pregnancy or not: women were asked whether the pregnancy was planned or not.
- Satisfaction with the relationship: women were asked if they were in a relationship. If yes, they were asked: "How satisfied are you with the relationship?" Responses were very satisfied, somewhat satisfied, and not satisfied. For this study, this variable was dichotomized as satisfied and not satisfied.
- Personal history of depression: women were asked whether they have any of the following: history of depression, history of depression during previous pregnancy, and/or history of previous postpartum depression. Their responses to these questions were summarized in one dichotomized variable that has two levels, yes for any history of past depression and no for no history of any form of depression.

3.2.5. Behavioral factors.

- Smoking: women were asked, “in the last month, how much do you smoke?” Responses were More than a pack/day, 5-20/day, less than five a day, quit since pregnant, quit before pregnancy, and never smoked. Their responses were summarized into a dichotomized variable, “yes” and “no or quit”.
- Alcohol: women were asked, “How often did you drink beer or other alcohol?” Responses were occasional a drink or two, 1-2 drinks a day, five or more drinks at one time, quit since pregnant, quit before pregnancy, and never drank alcohol. Their responses were summarized into a dichotomized variable, “yes” and “no or quit”.
- Drug use: women were asked, “How often did you use drugs such as marijuana, crystal meth, and cocaine?” Responses were regular (every day), occasionally, quit since pregnancy, quit before pregnancy, and never use such drugs. Their responses were summarized into a dichotomized variable, “yes” and “no or quit”.
- Exercise: women were asked, “in the last month, how much do you exercise?” Choices were every day, 2-3 times per week, occasionally, and never. Exercise variable was used as a dichotomous variable with two levels, “regular exercise” and “never or occasionally”

3.3. Data Analysis

3.3.1. Descriptive statistics. We started the data analysis by running a descriptive statistical analysis to summarize characteristics of participants at baseline. We also calculated the prevalence rates of depression (EPDS>12) and anxiety (EPDS-A>4) at each time point. In addition, we summarized the EPDS scores and EPDS-anxiety subscale scores of participants at each point of assessment for the total sample, as well as scores stratified by trajectory groups. Group specific descriptive statistical analyses were also conducted to illustrate characteristics of women who belonged to each of the depressive and anxiety trajectory groups.

3.3.2. Group-based trajectory models. The group-based modeling strategy was used to identify trajectories of maternal depressive symptoms based on the total EPDS scores and anxiety symptoms based on their EPDS-A scores during the perinatal period (from early pregnancy to early postpartum) as well as during the period between early pregnancy and fifth year postpartum. The group-based modeling is a semiparametric, group-based approach for modeling developmental trajectories that is easy to apply and very flexible (Nagin, 1999). The purpose of this method is to determine distinct clusters of developmental trajectories (Nagin, 1999). Group-

based trajectory model is an application of finite mixture models (Nagin, 2005), which assumes that the population is composed of a finite number of distinct groups that are clustered based on their symptom trajectories, either depressive or anxiety (Nagin & Odgers, 2010). It allows for the identification of clusters of individuals who follow a similar evolution of behavior, in this case depression or anxiety over time, which can be summarized by a finite number of polynomial functions of time that are specific to each trajectory group "*j*" (Nagin, 2005), and they take the following general form:

$$P(Y_i)=\sum_{j=1}^{J} \pi_j P^j(Y_i) \quad (3.1)$$

where $P(Y_i)$ is the unconditional probability of $Y_{i,}$ with Y_i being a vector of the measured behavior for the *i*th individual at the assessment period t. $P^j(Y_i)$ is the probability of membership for individual *i* in trajectory group *j*. π_j is the probability of belonging to trajectory group *j* for a randomly chosen individual (Nagin, 2005).

The basic principle of the group-based analytical approach is its ability to estimate growth curves for each individual in the sample, and then to identify prototypal growth curves based on the individual curves (Campbell et al., 2007). Once identified, these prototypal group curves are meant to describe patterns of progression of depressive and anxiety symptoms over time that best fit the data (Campbell et al., 2007). Individuals with similar growth curves are then assigned into different trajectory groups based on similarity of their individual depressive or anxiety score patterns to those of one of the trajectory groups. This assignment rule assumes that between-groups variation in depressive or anxiety scores is more relevant than within-group variation (Campbell et al., 2007). This method is of particular importance in the case of maternal depressive and anxiety symptoms, as it allows for capturing the diversity of these symptoms in terms of onset, course, timing, and severity (Gross, Shaw, Burwell, & Nagin, 2009).

Group-based trajectory models provide an estimation of model parameters for each trajectory, allowing the magnitude and direction of change of depressive or anxiety symptoms to vary between different trajectories (Nagin, 2005). Another important feature of a group-based trajectory model is that it does not require prior information on the number and shape of groups; rather, it uses the available data to estimate the best number and shape of trajectories groups that fits the data, as well as the proportion of the population that belongs to each of these trajectories (Nagin, 1999). Furthermore, group-based modeling recognizes uncertainty in group membership and also allows for the consideration of the effect multiple risk factors or covariates on group

membership (Nagin, 1999). The PROC TRAJ procedure in SAS was developed by Jones and colleagues to estimate group-based trajectories models (Jones & Nagin, 2007; Jones, Nagin, & Roeder, 2001). It uses a general quasi-Newton procedure to calculate parameter estimates that maximize the likelihood function (Nagin, 2005).

Censored normal distribution-based model. One must first decide the appropriate data distribution for modeling the shapes of the latent trajectory profiles over time. Censored normal distribution-based (CNORM) model is used for psychometric scale data, which usually shows clustering of data at the scale's minimum and/or maximum (Nagin, 2005). In our study, depression and anxiety tend to cluster at the minimum value, which can lead to a skewed distribution. As such, we chose to use CNORM model.

For the CNORM model, a latent variable (y_{it}^*) serves as a linkage between time and behavior of interest (i.e. maternal depressive or anxiety scores). This latent variable measures the tendency of the individual *i* to have a specific behavior score at the time of assessment *t* given membership in group *j* (Nagin, 2005). Suppose that y_{it} is the observed but censored counterpart of the latent variable y_{it}^* and it is censored between the minimum and the maximum values of the psychometric scale (the EPDS scale for depression and the EPDS-A scale for anxiety). When the y_{it}^* is less than that minimum value of the psychometric scale, y_{it} equals to that minimum value. When y_{it}^* is greater than that maximum value of the scale, y_{it} equals to that maximum value. When y_{it}^* lies between the minimum and maximum values of the scale, y_{it} equals the y_{it}^* (Nagin, 2005).

To best characterize the trend of each trajectory group over time, a polynomial function is used to model the relationship between behavior and time (Nagin, 1999). Polynomial order determines the shape of the trajectory. For instance, for a model with cubic polynomial, the latent variable measuring the true behavior of interests for individual *i* at time *t* is modeled as,

$$y_{it}^* = \beta_0^j + \beta_1^j T_{it} + \beta_2^j T_{it}^2 + \beta_3^j T_{it}^3 + \varepsilon_{it} \quad (3.2)$$

where T_{it}, T_{it}^2, and T_{it}^3 are the linear, quadratic, and cubic terms for the follow up time and ε_{it} is a disturbance term that is assumed to be normally distributed with a mean of 0 and a constant variance of σ^2.

Parameters β_1^j, β_2^j , and β_3^j define the shape of the trajectory for each group *j*. Distinctive parameters are estimated for each group *j*, which allows the shape of trajectories to vary between groups (Nagin, 2005). Trajectories with intercept only exhibit a constant behavior over time

whereas a significant quadratic term can capture trajectories with an increasing, decreasing, decreasing then increasing, or increasing then decreasing trends. However, the quadratic term only allows for a single turning point with a symmetrical amount of change on both sides (same magnitude of increase or decrease). Adding the cubic term gives even more flexibility by allowing for more than one turning point, and by accommodating asymmetrical changes around each turning points.

The optimal number of groups and shape of trajectories. Different models with a varying number of groups and shapes of the trajectories must be compared to find the model that best fits the data. Bayesian information criterion (BIC) is used to determine the optimal number and shape of trajectory groups (Nagin, 1999).

The BIC is calculated as follows:

$$\text{BIC}=log(L)-0.5k\ log(N) \tag{3.3}$$

where L is the value of the model's maximized likelihood, N is the sample size, and k is the number of parameter in the model. Based on the equation, it can clearly be seen that the BIC rewards parsimony by adding a penalty for the addition of more parameter into the model (Nagin, 2005).

The Bayes factor, denoted as B_{ij}, can be used to determine how significant is the difference between BIC scores of two models, denoted as model i and model j, which is a ratio of the probability of model i being the correct model to model j being the correct model (Nagin, 2005). The Bayes factor value is calculated based on the BIC scores of the two models using the formula:

$$B_{ij} = e^{\text{BIC}_i - \text{BIC}_\text{j}} \tag{3.4}$$

Using Jeffreys's scale of evidence of Bayes factor, the strength of evidence to select a specific model based on BIC values can be determined (Wasserman, 2000).

A related measure that can be used to help identify the best model among more than two models is the p_j, which is the probability that the model j is the correct model among a set of J different models. The p_j can be estimated using the following equation:

$$p_j = \frac{e^{\text{BIC}_j - \text{BIC}_\text{max}}}{\Sigma_j\, e^{\text{BIC}_j - \text{BIC}_\text{max}}} \tag{3.5}$$

A two-stage model selection strategy was used to find the best number of groups and shape of trajectories that fit the data (Nagin, 2005). In the first stage, we started to test models

that consisted of two groups with cubic degree polynomial, and then we increased the number of groups from two to six with trajectories that are all cubic, guided by information from previous literature (Bayrampour et al., 2016; Campbell et al., 2007; Cents et al., 2013; Gross et al., 2009; Kuo et al., 2014; Luoma et al., 2015; Skipstein et al., 2010; van der Waerden et al., 2015). Once the number of groups was identified based on model selection criteria (BIC, Bayes factor, and the probability of being the correct model), a backward elimination method was used to alter the order of trajectories. Non-significant cubic, quadratic, and linear terms were removed sequentially, and each model was retested to check the BIC value until all terms in the model were significant (linear, quadratic, and/or cubic). Beside statistical criteria, theoretical considerations such as the expected number and shape of trajectories, as well as the interpretability of these trajectories were also considered (Campbell et al., 2007).

Group membership probabilities. The probability of membership in group j, j=1, 2, …J; π_j, is linked to a set of parameters that define the shape of each trajectory; θj by the following equation:

$$\pi_j = \frac{e^{\theta_j}}{\sum_{j=1}^{J} e^{\theta_j}}. \tag{3.6}$$

Even though θ_j can take any value, this equation ensures that π_j always lies between 0 and 1, and that π_j of all J groups sum to 1 (Nagin, 2005).

Posterior group membership probabilities. The posterior group membership probability [$\hat{P}(j|Y_i)$] is the probability of membership in group j for each i individual (Nagin, 1999). It is calculated based on the individual's longitudinal pattern of behavior (depression and/or anxiety) using the following equation:

$$\hat{P}(j|Y_i) = \frac{\hat{P}(Y_i|j)\hat{\pi}_j}{\sum_{j=1}^{J} \hat{P}(Y_i|j)\hat{\pi}_j}, \tag{3.7}$$

where $\hat{P}(Y_i|j)$ is the estimated probability of observing i's actual trajectory, given membership in j, and it can be estimated based on trajectory parameters, and $\hat{\pi}_j$ is the estimated proportion of the population in group j (Nagin, 2005).

Individuals are assigned to groups to which their posterior probability is the highest (Nagin, 1999), i.e., the group to which they are more likely to belong based on their behavior pattern. Assigning individuals to trajectory groups allows for identifying characteristics of individuals who belong to each of the identified groups. It also provides the basis for statistically

linking trajectory groups to various maternal sociodemographic, psychosocial, and behavioral characteristics in our current study.

3.3.3. Model diagnostics. To check whether the model fits the data well, several model diagnostics can be used (Nagin, 2005), which are outlined below.

The average posterior probability of assignment. The average posterior probability of assignment ($AvePP_j$) can be calculated for each group (Nagin, 2005). A minimum of 0.7 for all groups is considered acceptable, whereas above 0.8 for all groups is recommended (Nagin, 2005).

The odds of correct classification. The other model fit diagnostic is the odds of correct classification for a trajectory group j (OCC_j), which is calculated as follows:

$$OCC_{j\,j}=\frac{AvePP_j/1-AvePP_j}{\hat{\pi}_j\,/1-\hat{\pi}_j} \tag{3.8}$$

where $\hat{\pi}_j$ is the estimated proportion of the population in group j, and $AvePP_j$ is the average posterior probability of assignment (Nagin, 2005).

If the maximum probability assignment rule had no predictive capability beyond chance, the OCC_j would be one (Nagin, 2005). As the $AvePP_j$ becomes closer to one, the value of OCC_j would increase. Therefore, larger values of OCC_j indicate a better fit. Nagin recommended an OCC_j greater than 5 for all groups (Nagin, 2005).

The estimated group probability versus proportion of sample assigned to the group. Model estimations provide two estimates of the probability of group membership, one is the $\hat{\pi}_j$ and is calculated as illustrated in Section 3.2.2., equation 6. The other alternative is the proportion of sample subjects who belong to each group based on the maximum posterior probability assignment rule (P_j), and it equals to the number of subjects belong to each group divided by the total sample size (Nagin, 2005). Under perfect conditions, the $AvePP_j$ would be 1 and the $\hat{\pi}_j$ and P_j would have the same value. As assignment errors increase, both values would become increasingly dissimilar (Nagin, 2005).

Confidence interval for group membership probability. We calculated the 95% confidence intervals for membership probability ($\hat{\pi}_j$) for each group. In general, a narrower confidence interval for $\hat{\pi}_j$ indicates a better model fit (Nagin, 2005).

3.3.4. Expanding the model by including predictors of trajectory group membership. To expand the model, risk factors can be included in the model to determine the trajectory group membership, Nagin suggested a three stages procedure (Nagin, 2005). The first stage involves the identification of number and shape of trajectories without the inclusion of any risk factors, as was

described in the previous sections. Group membership is obtained using the maximum posterior probability assignment rule based on model estimations in this stage (Nagin, 2005). The second stage involves recognizing significant risk factors that are associated with group membership. This can be done by fitting a multinomial logit models using group membership as the response variable to predict the effect of various maternal characteristics on the probability of belonging to a specific trajectory class, compared to a reference group (Nagin, 2005). Once significant risk factors were identified, the third stage can be commenced by jointly estimating the parameters defining group trajectories and group membership probabilities with the inclusion of risk factors in the model (Nagin, 2005).

Multinomial logit models. Multinomial logit models (the generalized logit models) are used to model the relationship between a nominal response variable that has greater than two categories and a set of predictor variables to create a combination several binary logistic regression models that are calculated instantaneously (So & Kuhfeld, 1995). For a response variable with *J* categories, we need only *J*-1 equations to contrast categories 1,2, …..*J*-1 with category *J* (Agresti & Kateri, 2011). The following is the general multinomial logit model:

$$Log\left[\frac{Yi=[1|xi1,\ldots..xiK]}{Yi=[J|xi1,\ldots..xiK]}\right]=\beta_{10}+\beta_{11}x_{i1}+\ldots\ldots+\beta_{1K}x_{iK}$$

$$\vdots$$

$$Log\left[\frac{Yi=[2|xi1,\ldots..xiK]}{Yi=[J|xi1,\ldots..xiK]}\right]=\beta_{20}+\beta_{21}x_{i1}+\ldots\ldots+\beta_{jk}x_{iK}$$

$$\vdots$$

$$Log\left[\frac{Yi=J-1|xi1,\ldots..xiK]}{Yi=J|xi1,\ldots..xiK]}\right]=\beta_{(J-1)0}+\beta_{(J-1)1}x_{i1}+\ldots\ldots+\beta_{(J-1)K}x_{iK} \quad (3.9)$$

where $\left[\frac{Yi=[1|xi1,\ldots..xiK]}{Yi=[J|xi1,\ldots..xiK]}\right]$, $\left[\frac{Yi=[j|xi1,\ldots..xiK]}{Yi=[J|xi1,\ldots..xiK]}\right]$, $\left[\frac{Yi=[J-1|xi1,\ldots..xiK]}{Yi=[J|xi1,\ldots..xiK]}\right]$ are the odds of belonging to trajectory group 1, *j,* and *J-1* versus trajectory group *J* respectively; β_{10}, β_{20}, … β_{J0} are intercepts; β_{1k}, β_{2k}, … $\beta_{(J-1)k}$, $_{k=1,\ldots K}$ are the regression coefficients for the covariates x_{i1}, x_{i2} …., $x_{iK,}$, respectively.

In our analysis, we fitted a multinomial logit model using group membership as the dependent variable to study the associations of various maternal characteristics on the probability of belonging to a specific trajectory group compared to a reference group. Bivariate analyses were initially conducted to test for association between maternal sociodemographic,

psychosocial, and behavioral characteristics at baselines and the trajectory group membership. Next, a multivariate multinomial regression model was built by including all variables that were statistically associated with the outcome variable ($p<0.25$) based on bivariate analyses. Using a backward elimination procedure, we excluded all independent variables that were insignificant ($p>0.05$) from the model. All the above-mentioned steps of data analysis were conducted separately for depression and anxiety during the perinatal period; and depression and anxiety from pregnancy to five years postpartum.

Assessing the impact of various predictors on the probability of membership in each group. Nagin (2005) highlighted few measures that can assess the magnitude of the impact of significant covariates on the probability of group memberships. One measure is the odds ratio (OR), which measures the amount of change in group membership probability (within each group) per unit change in the covariate included in the model.

The other measure is the calculation of the probability of group membership in each group, based on covariates included in the model (Nagin, 2005). This can be done by jointly estimating the parameters defining group trajectories and group membership probabilities with the inclusion of risk factors in the model. These analyses will account for the participants' probabilities of membership to the other trajectories, and thus will consider the uncertainty of the assigned group membership (Nagin, 2005). To measure the magnitude of the effect of significant covariates on trajectory group membership probabilities, we calculated the group membership probabilities for each group after including covariates using equation 3.6 (Nagin, 2005).

3.3.5. Missing data. Missing data is a common problem in longitudinal studies (Haviland, Jones, & Nagin, 2011), and the FIP study is no exception. The FIP data has a significant amount of missing data, especially in year three and five of the follow-up. Different statistical techniques were used to understand the nature of missing observations in our data. We first summarized the group-specific number of missing observations. We also compared the mean and median EPDS scores for participants with and without missing data within each depression group and the mean and median EPDS-A scores for participants with and without missing data within each anxiety group. Next, we created a new dropout categorical variable with four levels: 0 for no missing observations; 1 for one missing value for the outcome variable either at time 4 or time 5 of the follow-up; 2 for 2 missing values of the outcome variable at time 4 and 5; and 3 for 3 missing values of the outcome variable at time 3, 4, and 5 of the follow-up. We then fitted a

multinomial logit regression model with depressive or anxiety trajectory group membership as the outcome variable and the new dropout categorical variable as the predictor to understand the difference between groups in terms of missing values of the outcome variable (EPDS scores or EPDS-A scores). We also fitted a multinomial regression model with the dropout categorical variable as the outcome variable, and individual maternal risk factors as covariates to identify the difference between women who dropped out of the study and women who did not drop as to their baseline characteristics. Another statistical analysis we utilized is the nonparametric test "Wilcoxon rank sum" test to examine for the difference in the distribution of EPDS or EPDS-A scores between participants with and without missing values of those scores per each depression or anxiety trajectory group. We chose this non-parametric test because of the skewness of the distribution of EPDS and EPDS-A scores in our data.

Nagin (2005) recommended individuals with some missing data should be included in the analyses to minimize bias. Under the missing at random assumption, the PROC TRAJ handles missing data using maximum likelihood estimation to estimate model parameters, given that there are at least two observations per individual (Haviland et al., 2011; Campbell et al., 2007). Haviland and colleagues developed an extension to account for missing data due to participants' attrition, either because of truncation, censoring, or intermittent missed assessment (Haviland et al., 2011). We used the dropout statement extension of the PROC TRAJ procedure in SAS, and we compared models with and without the dropout extension to check the magnitude of change in parameter estimates, as well as group membership probabilities. Whereas the basic model accommodates missing data by assuming it is missing at random (Nagin, 2005), the dropout statement accounts for attrition, allowing for the direct modeling of the attrition process (Haviland et al., 2011). Using this extension, the elements of Y_i and y_{it} are redefined to account for participants' dropout. Still, y_{it} equals its defined value prior to dropout, but once there is a dropout, y_{it} is labeled as missing. Thus, the revised likelihood identifies the joint probability of the defined values of y_{it} before dropout and their missingness after the dropout (Zimmer, Martin, Nagin, & Jones, 2012).

Haviland and colleagues considered this extension a form of latent ignorability, where missingness is assumed ignorable within the latent groups (Haviland et al., 2011). Since trajectory groups are non-observable, this extension addresses a special form of non-ignorable missing data, where attrition is a function of observed outcomes, observed covariates, as well as

unobserved trajectory group membership (Haviland et al., 2011). Moreover, this extension assumes that missing data are independent of unobserved outcomes within trajectory groups (Haviland et al., 2011).

The basic model assumes that trajectory probabilities is independent on the attrition. Though, the model with the dropout extension does not adhere to this assumption, allowing the dropout probability to vary between groups (Haviland et al., 2011). The calculated dropout probability can differ across groups and may vary as a function of observed outcomes before the dropout, and/or other covariates (Haviland et al., 2011). Hence, dropout probability for each group, trajectory specific attrition rates, as well as trajectory group probabilities after attrition are estimated (Haviland et al., 2011). Haviland and colleagues noticed that when trajectory groups are well separated, trajectory membership will be estimated with great certainty, and missing values will be missing at random (Haviland et al., 2011). On the other hand, when trajectory groups are not well separated, bias will be introduced if the model does not address nonrandom missing data (Haviland et al., 2011). The application of this extension on simulated and real data has shown that results about group size can be significantly different after using this extension (Haviland et al., 2011).

Chapter 4: Manuscript 1

This manuscript was submitted to the *BMC Psychiatry* Journal. The first author, Asma Ahmed, reviewed the relevant literature to do the analysis, analyzed the data using the appropriate statistical analytical procedure, interpreted the results, and drafted the manuscript.

Latent Trajectory Groups of Maternal Depressive and Anxiety Symptoms from Pregnancy to Early Postpartum and their Antenatal Risk Factors

Asma Ahmed, Cindy Feng, Angela Bowen, and Nazeem Muhajarine
University of Saskatchewan

Abstract

Background: There is a growing evidence that perinatal depressive and anxiety symptoms are heterogeneous with their symptom syndromes and trajectories, which may be determined by risk factors specific to each subtype. Understanding this heterogeneity is critical to the development of preventative and intervention measures directed towards women at high risk. The aim of this study is to identify subgroups of individuals who exhibit distinct longitudinal trajectory patterns of depressive and anxiety disorders from pregnancy to early postpartum and the risk factors associated with these trajectory groups.

Methods: Women (n=615) from the Feelings in Pregnancy and Motherhood (FIP) longitudinal study were followed from early pregnancy to early postpartum in 2006-2007. The semiparametric group-based trajectory modeling approach was used to determine the optimal shape and the number of latent trajectory groups for perinatal depressive and anxiety symptoms, as well as the proportion of sample belonging to each trajectory groups. Multinomial logit models were used to explore the association between identified latent trajectory groups and various maternal characteristics.

Results: We identified four trajectories groups of perinatal depressive symptoms: low-stable (49.6%); moderate-stable (42.3%); postpartum (3.6%); and antepartum (4.6%). Significant risk factors associated with the moderate-stable group relative to the low-stable group were past depression [adjusted odds ratio (aOR) 2.66, 95% confidence interval (CI) (1.79-3.94)] and high stress level [aOR 2.49, 95% CI (1.70-3.64)]. Significant risk factors for the postpartum group relative to the low-stable group were age [aOR 5.30, 95% CI (2.00-14.03)] and high stress level [aOR 2.73, 95% CI (1.08-6.87)]. For the antepartum group, relative to the low-stable group, significant risk factors were non-Caucasian ethnicity [aOR 4.89, 95% CI (1.74-13.78)], past depression [aOR 11.02, 95% CI (3.40-35.69)], high stress level [aOR 10.52, 95% CI (2.89-38.26)], and poor relationship satisfaction [aOR 6.74, 95% CI (2.43-18.70)]. Three trajectory groups of perinatal anxiety were identified: very low-stable (8.9%); low-stable (60.7%); and moderate-stable (30.4%). Significant risk factors associated with the low-stable group relative to the very low-stable group was high stress level [aOR 3.90, 95% CI (1.60-9.52)]. Significant risk factors for the moderate-stable group relative to the very low-stable group were past depression [aOR 4.44, 95% CI (1.94-10.26)] and high stress levels [aOR 6.73, 95% CI (2.67-16.99)]. Low income was significantly associated with moderate-stable group relative to the low-stable group

[<$20,000 versus >$60,000: aOR 2.92, 95% CI (1.62-5.25); 40-$60,000 versus >$60,000: aOR 2.08, 95% CI (1.28-3.40)].

Conclusion: Latent trajectory groups of perinatal depressive and anxiety symptoms were identified, which were associated with different profiles of risk factors present prior to or during pregnancy. Our findings support the need for multiple assessments starting from early pregnancy to the postpartum, which may help to recognize women at high risk of major depression or anxiety. All significant risk factors can be identified during regular follow-up and thus, clinicians may be able to identify women at high risk, who may be potential candidates for early interventions that may alter the progress of their mental symptoms.

Keywords: Longitudinal trajectories, group-based trajectory analysis, perinatal depression, perinatal anxiety, mood disorders, risk factors.

4.1. Introduction

Perinatal depression and anxiety are issues of global significance. Approximately 14-25% of expectant mothers and 8-15% of postpartum women experience depression (Onunaku, 2005), and up to 24% of pregnant women have anxiety symptoms (Grant, McMahon, & Austin, 2008). As many as 75% of women with antenatal depression also suffer from postpartum depression, and about 50% of women with antenatal anxiety go on to have postnatal anxiety (Grant et al., 2008). Moreover, the presence of anxiety symptoms during pregnancy is strongly associated with increased risk of postpartum depression (Sutter-Dallay et al., 2004). Screening positive for perinatal depressive symptoms is associated with poor outcomes for the mother, her relationship, mother-infant bonding, and child development (Bernard-Bonnin et al., 2004; Bosquet & Egeland, 2001; Reay, Matthey, Ellwood, & Scott, 2011). Depressive and anxiety disorders are found to be heterogeneous in their symptom syndromes and trajectories, which may be determined by risk factors specific to each subtype (Nandi et al., 2009). Understanding this heterogeneity is critical to the development of preventative and interventions tailored to specific prenatal depressive or anxiety symptom profiles.

Research has documented the trajectories of depression, but few studies have clustered the trajectories and linked them to sociodemographic, cultural, psychological, and psychosocial factors, particularly in perinatal women. Mora and colleagues followed 1,735 low-income, inner-city US women from pregnancy to two years postpartum and identified five depression trajectories: never depressed (the largest class), antepartum only, postpartum, late postpartum, and chronic trajectory (Mora et al., 2009). Another study of low-risk women in France identified four trajectories of maternal depressive symptoms in 1,807 women from pregnancy to two years postpartum: never depressed, postnatal, chronic persistent, and chronic with exacerbation during pregnancy (Sutter-Dallay et al., 2012). A Finnish study looked at mental health trajectories from early pregnancy to one year postpartum and identified five trajectory groups of maternal mental health symptoms, with the majority of the women (75%) having no symptoms; the other four classes were antepartum (6%), early postpartum (9%), late postpartum (6%), and high-level symptoms (4%) (Vänskä et al., 2011). Despite the cultural and socioeconomic differences between these study populations, 70-75% of the women in all of the studies belonged to the never depressed group. This implies that regardless of income and socioeconomic status, about three-quarters of women are unlikely to exhibit depressive symptoms during pregnancy and

postpartum. Nevertheless, these studies show that a minority of women experience persistent high depressive symptoms with varying trajectory patterns—this validates the heterogeneous nature of the symptom trajectories, which this study sought to demonstrate.

Depressive and anxiety disorders frequently co-occur, but may have heterogeneous courses over time. Limited studies have looked at the course of anxiety symptoms in pregnancy and/or postpartum and in the studies where it is reported, the findings are mixed (Buist et al., 2011). Several studies have concluded that anxiety symptoms decrease during postpartum (Agrati et al., 2015; Figueiredo & Conde, 2011; Madigan et al., 2014). The reduction of anxiety symptoms postnatally could be attributed to the interaction between the mother and her baby, and if breastfeeding may be related to hormonal influences (Jonas et al., 2008; Macbeth & Luine, 2010). A recent Canadian study identified two anxiety trajectory groups from pregnancy to two years postpartum, with a U-shaped pattern and a stable linear pattern of anxiety symptoms (Agrati et al., 2015). Another study which followed women from pregnancy to nine months postpartum found two trajectory groups of anxiety symptoms; moderate stable and low declining (89.4%) (Don et al., 2014).

We have only found two studies that have examined the dual trajectories, perinatal depression and anxiety (Bayrampour et al., 2016; Kuo et al., 2014). A Canadian study identified five trajectory groups for depression and anxiety symptoms from pregnancy to one year postpartum, namely, minimal, mild, antepartum, postpartum, and chronic. The majority of women belonged to either the minimal or mild trajectories for depression and anxiety, whereas very small proportion of women were classified with chronic depression and anxiety (2.4% and 1.5% respectively) (Bayrampour et al., 2016). A study from Taiwan identified three depressive trajectory groups (low, mild, and high) and four anxiety trajectory groups (low, mild, high, and very high) (Kuo et al., 2014). These trajectories were stable throughout the period of follow-up, probably because of the smaller sample size, and the shorter time of follow-up (late pregnancy to six-months postpartum) compared to other studies (Kuo et al., 2014). They also found that depression groups were significantly associated with anxiety groups (Kuo et al., 2014).

In previous studies that linked depression and/or anxiety trajectories to maternal characteristics, similar profiles of women who belonged to high level symptom trajectories were found, regardless of the study population. Women in the higher depression and/or anxiety symptom trajectories were typically younger, had lower income, education, social support, and

relationship satisfaction, higher stress levels, and were more likely to have a history of mental illness than those in the none or lower symptom trajectories (Bayrampour et al., 2016; Mora et al., 2009; Sutter-Dallay et al., 2012).

Findings from studies that explored the heterogeneity of depressive and anxiety symptoms have focused on different follow-up time periods. Many studies have included women who were more vulnerable to develop maternal mood disorders (Christensen, Stuart, Perry, & Le, 2011; Gross et al., 2009; Mora et al., 2009), and several started follow-up in late pregnancy (Kuo et al., 2014; Sutter-Dallay et al., 2012; Vänskä et al., 2011), and hence did not capture the pattern of the progress of mental symptoms across the entire pregnancy and beyond. As such, there is a paucity of research that identifies latent trajectory groups of both depressive and anxiety symptoms, especially in the perinatal period.

To gain a better understanding of the longitudinal patterns of perinatal depression and anxiety symptoms and associated antenatal risk factors, we used data from the Feelings in Pregnancy Study to answer the following questions: 1. What are the distinct trajectory patterns for depressive symptoms over a period of seven months from early pregnancy to early postpartum; what risk factors are associated with the identified perinatal depressive trajectory group membership? and 2. What are the distinct trajectory patterns for anxiety symptoms over a period of seven months from early pregnancy to early postpartum; what risk factors are associated with the identified perinatal anxiety trajectory group membership?

4.2. Methods

4.2.1. Sample. Our study included 615 women from the Feeling in Pregnancy and Motherhood study (FIP); a longitudinal study that was conducted between 2006 and 2013 in Saskatchewan, Canada. Details of the FIP study were well described elsewhere (A. Bowen, Bowen, Butt, Rahman, & Muhajarine, 2012; Rahman et al., 2014). Briefly, women were eligible to participate if they were: 1. within the first 20 weeks of pregnancy, 2. able to speak English, and 3. residing in one of two regional health authorities in Saskatchewan (Saskatoon Health Region and Five Hills Health Region). Data was collected via face-to-face individual interviews twice during pregnancy; early (at 17.4 +/- 4.9 weeks of gestation), and late (at 30.6 +/- 2.7weeks of gestation); and at early postpartum (at 4.2 +/-2.1 weeks postpartum). Ethical approval from the office of research Ethics at the University of Saskatchewan was obtained.

4.2.2. Measures.

Perinatal depressive symptoms. Depressive symptoms were assessed using the Edinburgh Postnatal Depression Scale (EPDS) (Cox et al., 1987). The EPDS is one of the most commonly validated screening tools for detection of perinatal depression (Cox et al., 1987), but it is also validated for the screening of antenatal depression (Buist et al., 2002). It includes questions about anxiety symptoms (Cox et al., 1987). The EPDS is unique to the perinatal period as it does not include any questions about the somatic symptoms of depression, such as sleep changes and fatigue, which often overlap with common symptoms of pregnant and postpartum women (Cox & Holden, 2003). It is a 10-item self-rated measure that is completed in less than 5 minutes (Cox et al., 1987; The American College Of Obstetricians & Gynecologists, 2015) with a sensitivity of between 59 and 100% and a specificity of 49–100% (The American College Of Obstetricians & Gynecologists, 2015). The EPDS items are presented on a Likert scale from zero to three with a maximum score is 30, and women with scores higher than 10 (within community settings) and 12 (within research studies) are probably depressed and they need further assessment (Cox et al., 1987).

Perinatal anxiety symptoms. The EPDS anxiety subscale (EDPS-A), which consists of item 3 ‘‘I have blamed myself unnecessarily when things went wrong’’), item 4 (‘‘I have been anxious or worried for no good reason’’), and item 5 (‘‘I have felt scared or panicky for no very good reason’’) was used to screen for anxiety symptoms. It was confirmed as a screening tool for anxiety symptoms during pregnancy (Bowen et al., 2008), as well as during the postpartum period (Ross et al., 2003). Responses to these items are reported on a Likert scale from zero to three with a maximum scale is nine and a cutoff point of five or more (Matthey, Valenti, et al., 2013).

Sociodemographic factors. Participants reported a variety of sociodemographic characteristic at the first point of assessment, including age (either <25 years or $\geq$ 25 years old), marital status (married/cohabiting or non-partnered), ethnicity (Caucasian or non-Caucasian), education (below grade 12 or grade 12 and higher), employment (employed or not employed), income per a year (social assistance/<$20,000, $20,000-$40,000, $40,000-$60,000, and >$60,000), and parity (0 or $\geq$1).

Psychosocial factors

Social support. Social support was measured by asking the participants, "Do you have someone to turn to for emotional support?" If they responded yes, they were asked to indicate people who provide them with social support. Responses to these questions were combined into one variable that indicates the level of social support, with 0-1 support treated as low-level of support while two or more supports considered as high-level of support.

Stress. Women were asked to indicate sources of stress from a list of stressors, which included work, place of living, the relationship with the partner, being pregnant, the health of the baby, the birth of the baby, school, own health, and other stressors. Their responses were combined into one variable that indicates the level of stress each participant experienced. This variable was dichotomized as low stress level (0-2 stressors) or high stress level (two or more stressors).

In addition, participants indicated whether the pregnancy was planned or not, and they were asked to indicate the level of satisfaction (very satisfied or not) with their relationship with the partner, if they have one. Furthermore, participants reported any history of depression in the past.

Behavioral factors. Participants also reported their smoking status (yes or no/quit), alcohol consumption (yes or no/quit), recreational drug use including marijuana (yes or no/quit), as well as their exercise level (regular or never/occasional).

4.2.3. Data Analysis. A semiparametric, group-based approach is used to determine distinct clusters of trajectory patterns of perinatal depressive and anxiety symptoms over the course of pregnancy to early postpartum (Nagin & Odgers, 2010). This approach allows for identification of clusters of women who follow a similar evolution of depressive or anxiety symptoms over time (Nagin, 2005). PROC TRAJ procedure in SAS was used, which was developed by Jones and colleagues to estimate group-based trajectory models (Jones et al., 2001). In our study, depression and anxiety tend to cluster at the minimum value, which can lead to a skewed distribution. As such, we chose to use the censored normal (CNORM) distribution (Nagin, 2005) to model the latent trajectory evolutions of both symptoms.

In order to identify the best number and shape of latent trajectory groups that fit our data, we used a two-stage model selection strategy (Nagin, 2005). In the first stage, we tested models with two to six trajectory groups that has the intercept, linear, and quadratic terms, guided by

information from the literature (Bayrampour et al., 2016; Kuo et al., 2014; Sutter-Dallay et al., 2012; Vänskä et al., 2011). Once the number of groups was identified based on model selection criteria (BIC, Bayes factor, and the probability of being the correct model), backward elimination was used to determine the order of trajectories. Non-significant quadratic and linear terms were removed consecutively, and each model was retested to check the BIC value until all terms in the model were significant (constant, linear, and/or quadratic). Beside statistical criteria, theoretical considerations, such as the expected number and shape of trajectory groups, as well as the interpretability of these trajectory groups were also considered (Campbell et al., 2007).

Women were assigned to the group which their posterior probability was the highest, i.e., the group to which they were more likely to belong based on their depressive or anxiety symptoms pattern (Nagin, 2005). Assigning women to latent trajectory groups allowed for identifying characteristics of those who belong to each of the identified trajectory groups (Nagin, 1999). It also provided the basis for statistically linking latent trajectory groups to maternal sociodemographic, psychosocial, and behavioral characteristics (Nagin, 1999). To check whether the model fit, we used several diagnostics measurements, namely the average posterior probability of assignment (values above 0.7 for all groups indicate a good model fit), the odds of correct classification (values above 5 for all groups suggest a good model fit), a close correspondence between the estimated group probability versus proportion of sample assigned to the group, and narrow confidence intervals for group membership probabilities (Nagin, 2005). The PROC TRAJ SAS procedure calculates the standard errors of the trajectories and the group membership probabilities using a first-order Taylor series expansion (Jones & Nagin, 2007).

Next, we fit a multinomial logit model using group membership as the dependent variable to determine whether various maternal characteristics are significantly associated with symptom subgroups (Agresti & Kateri, 2011; Nagin, 2005). Bivariate analyses were initially conducted to test for association between maternal sociodemographic, psychosocial, and behavioral characteristics at baselines and the trajectory group membership. A multivariate multinomial regression model was built by including all variables that were statistically associated with the outcome variable ($p<0.25$) based on bivariate analyses. Using backward elimination procedure, we excluded all independent variables that were insignificant ($p>0.05$) from the model sequentially. Once significant risk factors were identified, we repeated the analyses in the PROC TRAJ procedure, including the risk factors. This step was recommended by Nagin to account for

the uncertainty of group assignment, and to ensure that standard errors are properly calculated (Nagin, 2005). Adding risk factors to the trajectory analysis also allowed us to calculated the predicted group membership probabilities for each group after including covariates (Nagin, 2005). These analyses were performed using SAS software version 9.4.

4.3. Results

The sample was mostly composed of primiparous, married or cohabitating, Caucasian women who were older than 25 years and with high income and high education level. Only four percent% of participants had less than grade 12 education, and one-third had an annual income less than $40,000. Almost 80% of participants were employed at entry into the study. Most participants (88%) were satisfied in the relationship with their partner, almost two-thirds of them had planned their pregnancy, and most (83%) had a high level of social support. However, 40% of the women had high stress levels, and 30% had experienced depression in the past. In addition, the sample had a low prevalence of negative health behaviors. Only 10% of the women reported smoking, 6% reported alcohol use, and 3% reported drugs use including marijuana. More than a half of participants exercised on a regular basis (see Table 1).

Table 1. *Sociodemographic, psychosocial, and behavioral characteristics of FIP cohort study participants, N = 615, and by perinatal depression and anxiety trajectories [n (%)].*

Maternal characteristics	Total (n=615)	Depression Trajectories				*p*
		Low-stable (n=305)	Moderate-stable (n=260)	Postpartum (n=22)	Antepartum (n=28)	
Mother's age						<0.001
<25 years	96 (15.61)	31 (10.16)	46 (17.69)	9 (40.91)	10 (35.71)	
≥25 years	519(84.39)	274 (89.84)	214 (82.31)	13 (59.09)	18 (64.29)	
Parity						0.107
0	327 (53.26)	174 (57.24)	124 (47.69)	14 (63.64)	15 (53.57)	
≥1	287 (46.74)	130 (42.67)	136 (52.31)	8 (36.36)	13 (46.43)	
Education						0.027
< grade 12	24 (3.91)	8 (2.63)	10 (3.85)	2 (9.09)	4 (14.29)	
≥ grade 12	590 (96.09)	296 (97.37)	250 (96.15)	20 (90.91)	24 (85.71)	
Ethnicity						0.001
Caucasian	522 (85.02)	271 (88.85)	217 (83.78)	17 (80.95)	17 (60.71)	
Non-Caucasian	92 (14.96)	34 (11.15)	44 (16.21)	4 (19.05)	11 (39.29)	
Marital status						<0.001
No partner	57 (9.27)	16 (5.25)	29 (11.15)	3 (13.64)	9 (32.14)	
Partnered	558 (90.73)	289 (94.75)	231 (88.85)	19 (86.36)	19 (67.86)	

Maternal characteristics	Total (n=615)	Depression Trajectories				*p*
		Low-stable (n=305)	Moderate-stable (n=260)	Postpartum (n=22)	Antepartum (n=28)	
Employment						0.005
Yes	487 (79.45)	254 (83.28)	203 (78.38)	15 (68.18)	15 (55.56)	
No	126 (20.55)	51 (16.72)	56 (21.62)	7 (31.82)	12 (44.44)	
Income						<0.001
<$20,000	75 (12.46)	20 (6.69)	36 (14.12)	4 (19.05)	15 (55.56)	
20-$40,000	109 (18.11)	45 (15.05)	59 (23.14)	2 (9.52)	3 (11.11)	
40-$60,000	129 (21.43)	62 (20.74)	58 (22.75)	5 (23.81)	4 (14.81)	
>$60,000	289 (48.01)	172 (57.53)	102 (40.00)	10 (47.62)	5 (18.52)	
Past depression						<0.001
Yes	217 (35.28)	63 (20.66)	122 (46.92)	8 (36.36)	24 (85.71)	
No	398 (64.72)	242 (79.34)	138 (53.08)	14 (63.64)	4 (14.29)	
Stress level						<0.001
Low (0-2)	362 (59.44)	223 (74.09)	125 (48.45)	11 (50.00)	3 (10.71)	
High (>2)	247 (40.56)	78 (25.91)	133 (51.55)	11 (50.00)	25 (89.29)	
Support level						0.018
Low (0-1)	104 (16.94)	38 (12.50)	55 (21.15)	3 (13.64)	8 (28.57)	
High (>1)	510 (83.06)	266 (87.50)	205 (78.85)	19 (86.36)	20 (71.43)	
Relationship satisfaction						<0.001
Satisfied	536 (87.73)	286 (94.39)	219 (84.56)	19 (86.36)	12 (44.44)	
Not	75 (12.27)	17 (5.61)	40 (15.44)	3 (13.64)	15 (55.56)	
Planned pregnancy						0.003
Yes	366 (59.51)	200 (65.57)	145 (55.77)	12 (54.55)	9 (32.14)	
No	249 (40.49)	105 (34.43)	115 (44.23)	10 (45.45)	19 (67.86)	
Smoking						<0.001
No or quit	548 (89.25)	285 (93.44)	226 (87.26)	19 (86.36)	18 (64.29)	
Yes	66 (10.75)	20 (6.56)	33 (12.74)	3 (13.64)	10 (35.71)	
Alcohol						0.449
No or quit	573 (93.17)	286 (93.77)	242 (93.08)	21 (95.45)	24 (85.71)	
Yes	42 (6.83)	19 (6.23)	18 (6.92)	1 (4.55)	4 (14.29)	
Drugs						0.400
No or quit	596 (97.07)	298 (98.03)	251 (96.54)	21 (95.45)	26 (92.86)	
Yes	18 (2.93)	6 (1.97)	9 (3.46)	1 (4.55)	2 (7.14)	
Exercise						0.020
Never or occasional	284 (46.18)	129 (42.30)	122 (46.92)	13 (59.09)	20 (71.43)	
Regular	331 (53.82)	176 (57.70)	138 (53.08)	9 (40.91)	8 (28.57)	

Maternal characteristics	Anxiety Trajectories			*p*
	Very low (n=55)	Low (n=373)	Moderate (n=187)	
Mother's age				0.004
<25 years	5 (9.09)	48 (12.87)	43 (22.99)	
≥25 years	50 (90.91)	325 (87.13)	144 (77.01)	
Parity				0.168
0	23 (41.82)	206 (55.38)	98 (52.41)	
≥1	32 (58.18)	166 (44.62)	89 (47.59)	
Education				0.166
< grade 12	3 (5.45)	10 (2.69)	11 (5.88)	
≥ grade 12	52 (94.55)	362 (97.31)	176 (94.12)	
Ethnicity				0.132
Caucasian	51 (96.23)	319 (85.52)	152 (81.72)	
Non-Caucasian	2 (3.77)	54 (14.48)	34 (18.28)	
Marital status				0.036
Non-partnered	4 (7.27)	27 (7.24)	26 (13.90)	
Partnered	51 (92.73)	346 (92.76)	161 (86.10)	
Employment				0.033
Yes	47 (85.45)	304 (81.72)	136 (73.12)	
No	8 (14.55)	68 (18.28)	50 (26.88)	
Income				<0.001
<$20,000	4 (7.27)	32 (8.72)	39 (21.67)	
20-$40,000	8 (14.55)	66 (17.98)	35 (19.44)	
40-$60,000	14 (25.45)	70 (19.07)	45 (25.00)	
>$60,000	29 (52.73	199 (54.22	61 (33.89	
Past depression				<0.001
No	8 (14.55)	105 (28.15)	104 (55.61)	
Yes	47 (85.45)	268 (71.85)	83 (44.39)	
Stress level				<0.001
Low (0-2)	47 (88.68)	237 (64.32)	78 (41.94)	
High (>2)	6 (11.32)	133 (35.68)	108 (58.06)	
Support level				0.075
Low (0-1)	5 (9.09)	59 (16.86)	40 (21.39)	
High (>1)	50 (90.91)	313 (83.14)	147 (78.61)	
Relationship satisfaction				0.010
Satisfied	51 (92.73)	334 (90.03)	151 (81.62)	
Not satisfied	4 (7.27)	37 (9.97)	34 (18.38)	
Planned pregnancy				0.024
Yes	38 (69.09)	231 (61.93)	97 (51.87)	
No	17 (30.91)	142 (38.07)	90 (48.13)	
Smoking				0.031
No or quit	52 (94.55)	339 (90.88)	157 (84.41)	
Yes	3 (5.45)	34 (9.12)	29 (15.59)	
Alcohol				0.856
No or quit	52 (94.55)	346 (92.76)	175 (93.58)	

Maternal characteristics	Anxiety Trajectories			*p*
	Very low (n=55)	Low (n=373)	Moderate (n=187)	
Yes	3 (5.45)	27 (7.24)	12 (6.42)	
Drugs				0.423
No or quit	0 (0.00)	360 (96.77)	181 (96.79)	
Yes	55 (100)	12 (3.23)	6 (3.21)	
Exercise				0.231
Never or occasional	25 (45.45)	163 (43.70)	96 (51.34)	
Regular	30 (54.55)	210 (56.30)	91 (48.66)	

Notes: p is the p-value associated with results of univariate multinomial regression analyses.

Almost 97% of the participants had completed the EPDS and EPDS-A at the three points of assessment and all participants have completed assessments at least twice. Women dropped out of the study either because of loss of follow-up or due to fetal or neonatal death. Previous missing data analysis of the FIP data found that women who dropped out of the study at time three significantly differed from the rest. They were significantly younger, had less education and income, were more likely to be of Aboriginal descent, to have unplanned their pregnancies, and to be depressed, as compared to women who completed all three assessments (Bowen, Bowen, Butt, Rahman, & Muhajarine, 2012).

Among participants, the prevalence of depression during the first point of assessment (early pregnancy) was 10%. In late pregnancy, this rate decreased to 7.8%, and further dropped to 5.6% at early postpartum. On the other hand, prevalence rates of probable anxiety were as high as 31% during early pregnancy, which dropped to 22.3% during late pregnancy, and to 18% at early postpartum (see Table 2).

Table 2. *Edinburgh Postnatal Depression Scale (EPDS) and 3-item Anxiety Scale (EPDS-A) at Each Assessment.*

	Time of assessment		
	Early pregnancy	Late pregnancy	Early postpartum
Edinburgh Postnatal Depression Scale			
Mean (SD)	6.75 (4.45)	6.19 (4.32)	5.59 (4.14)
No. (%) depressed (EPDS>12)	63 (10.24)	47 (7.82)	33 (5.57)
3-item Anxiety Subscale			
Mean (SD)	3.36 (2.03)	2.95 (1.93)	2.63 (2.00)
No. (%) anxious (EPDS-3>4)	190 (30.89)	134 (22.33)	106 (17.91)

Notes: SD, standard deviation; Range of EPDS score = 0–29; Range of EPDS-A scores = 0-9.

4.3.1. Identifying depression trajectory groups. Models with two to six groups were analyzed. We calculated BIC values for models with two to six groups to determine the best number of groups. The BIC values increased from the two-group to the three-group and then to the four-group model. After that, the BIC started to decrease gradually as further groups were added (refer to Table 3). The Bayes factor showed a strong evidence for the four-group model against the three-group and five-group model. Therefore, it appeared that the four-group model was the best fitting and most parsimonious model.

Table 3. *Model fit indices for perinatal depression trajectories with 2-6 groups.*

Number of groups	BIC (n=1808)	Probability of being the correct model	BIC (n=615)	Probability of being the correct model
2	-5028.0	0.0000	-5023.7	0.0000
3	-4999.4	0.0000	-4992.9	0.0000
4	**-4976.5**	**0.9995**	**-4967.9**	**0.9959**
5	-4984.2	0.0005	-4973.4	0.0041
6	-4997.2	0.0000	-4984.3	0.0000

Notes: BIC, Bayesian information criterion; n=1808, the total number of assessments used in model estimation across persons and time; N=615, the number of individuals in the estimation sample.

Inspection of parameter estimates for the four-group model showed that the constant and linear terms were significant for all groups, whereas the quadratic term was significant only for group three and four (see Table 4 for parameter estimates and observed trajectories).

Table 4. *Perinatal depression and anxiety trajectories parameter estimates (N=615).*

Group	N	%	Intercept	Linear	Quadratic
Depression groups					
Low-stable	305	49.59%	4.20***	-0.32*	-
Moderate-stable	260	42.28%	9.58***	-0.99***	-
Postpartum	22	3.58%	19.22***	-15.27***	4.88***
Antepartum	28	4.55%	11.13**	8.22**	-2.87**
Anxiety groups					
Very low-stable	55	8.94%	1.05*	-0.64**	-
Low-stable	373	60.65%	3.17***	-0.41***	-
Moderate-stable	187	30.41%	5.37***	-0.36***	-

Notes: *P<0.05. **P<0.01. ***P<0.001

Figure 1 depicts the four perinatal depressive trajectory groups with the dashed line represents the predicted trajectory whereas solid lines indicate the actual trajectories. The observed trajectories represent the mean scores for women who were assigned to each group, based on their posterior probabilities of group membership. Both predicted and observed trajectories seem to correspond well with each other, suggesting that the data fits the model well. Figure 2 shows the four perinatal depression trajectory groups with 95% confidence limits.

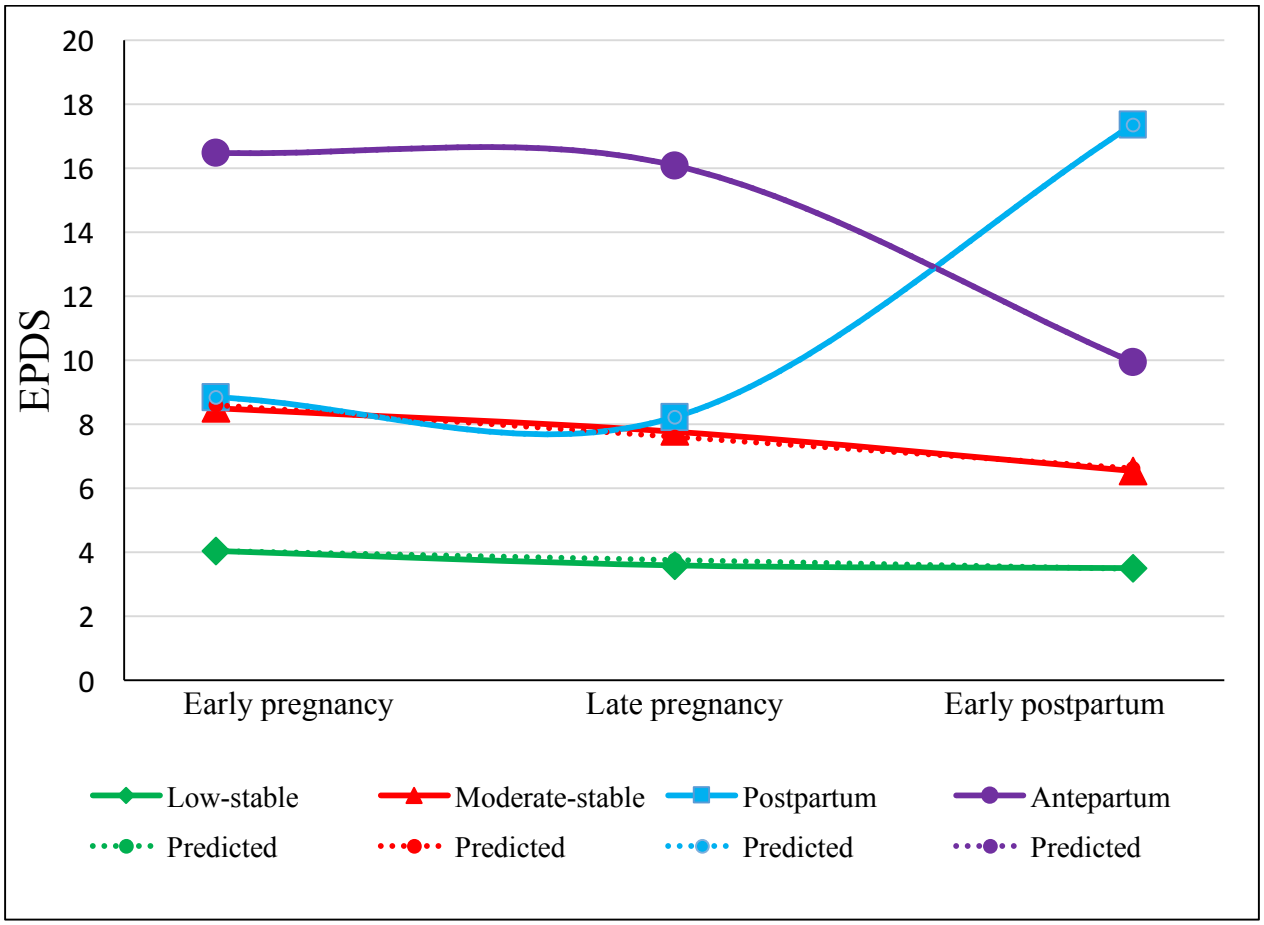


Figure 1. Observed versus predicted trajectory groups of perinatal depression symptoms of women from the FIP cohort study (n=615).

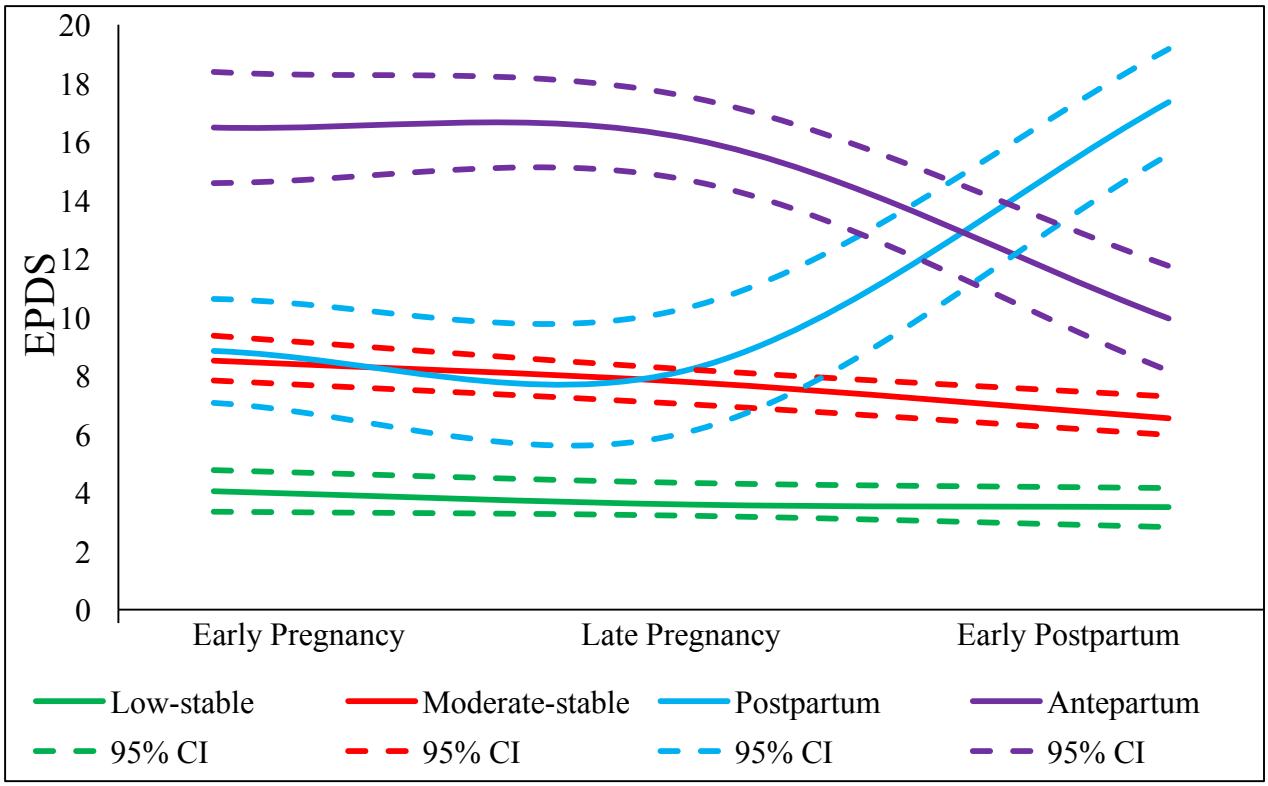


Figure 2. trajectory groups of perinatal depression symptoms of women from the FIP cohort study (n=615). Low-stable (48%), Moderate-stable (43%), Postpartum (4%), and Antepartum (5%).

The average posterior probability ranged from 0.83 for the moderate-stable group to 0.92 for the antepartum group (mean=0.87), indicating a very good model fit. In addition, the model met three other indicators of model adequacy; a close correspondence between the estimated group probability versus proportion of sample assigned to each group, based on the maximum posterior probability assignment rule; high odds of correct group classification relative to chance; and narrow confidence intervals for group membership probabilities (refer to Table 5).

Table 5. *Diagnostic statistics for judging model selection for trajectories of perinatal depression.*

Group	Average posterior probability	Proportion of sample assigned to group	Estimated group probability	Odds of correct classification	CI for group membership probability
1	0.86	0.50	0.48	6.56	0.44-0.53
2	0.83	0.42	0.43	6.49	0.38-0.47
3	0.88	0.04	0.04	188.75	0.03-0.05
4	0.92	0.05	0.05	220.35	0.04-0.06

The first and largest trajectory group "low-stable" was characterized by low baseline scores that consistently remained low across pregnancy to early postpartum. Almost half of women in the sample fell into this trajectory group (49.6%). The next largest trajectory group "moderate-stable" (42.3%,) included women whose depressive symptoms were stable with a mean higher than those of the low-stable trajectory. Around 90% of participants were included in those two groups. The third trajectory group "Postpartum" (3.6%) included women whose symptoms were slightly higher than women in the moderate-stable trajectory group during pregnancy. However, women in this group reported significantly higher depressive symptoms postnatally, as indicated by the significant quadratic term ($p<0.001$). As the estimated mean EPDS scores were well above 12 at the third point of assessment, those women possibly fulfilled the criteria of clinically significant postpartum depression. Women in the last trajectory group, "Antepartum" (4.6%) reported significantly high levels of depressive symptoms during pregnancy (the first two time points) with some decrease in severity after giving birth. Women assigned to this group reported EPDS scores as high as 19 during pregnancy, suggesting clinically significant symptoms. Mean values of EPDS scores by time and depression trajectories are summarized in Table 6.

Table 6. *EPDS scores [Mean (SD)] by time and trajectories of perinatal depression.*

	Time of assessment		
	Early pregnancy	Late pregnancy	Early postpartum
Low stable	3.83 (2.43)	3.40 (2.26)	3.37 (2.34)
Moderate stable	8.90 (3.17)	8.17 (3.17)	6.80 (3.02)
Postpartum	8.68 (4.03)	8.27 (4.22)	17.91 (2.96)
Antepartum	17.11 (4.37)	16.32 (4.35)	9.95 (4.74)

Notes: EPDS= Edinburgh Postnatal Depression Scale; the numbers of women in each trajectory are: low stable (n=305), moderate stable (n=260), postpartum (n=22), antepartum (n=28).

4.3.2. Identifying anxiety trajectory groups. Like the depression trajectory analysis, we identified anxiety trajectories by comparing BIC values of the two-group to six-group models. The BIC score increased from the two-group model to the three-group model. Afterward, the BIC values started to decrease as further groups were added (refer to Table 7). The Bayes factor indicated a strong evidence for the three-group model against the two-group and the four-group

model. Hence, we concluded the three-group model as the best fitting and most parsimonious model.

Table 7. *Model fit indices for perinatal anxiety trajectories with 2-6 groups*

Number of groups	BIC(m=1808)	Probability of being the correct model	BIC (n=615)	Probability of being the correct model
2	-3669.0	0.0000	-3664.7	0.0000
3	**-3655.9**	**0.9968**	**-3649.4**	**0.9318**
4	-3661.8	0.0026	-3653.2	0.0208
5	-3663.2	0.0007	-3652.4	0.0473
6	-3672.8	0.0000	-3659.8	0.0000

Notes: BIC stands for Bayesian information criterion; m=1808, the total number of assessments used in model estimation across persons and time; n=615, the number of individuals in the model estimation.

As to the parameter estimates for the three-group model, the constant and linear terms were significant for all groups. However, the quadratic term was not significant for any of the groups (see Table 4 for parameter estimates and observed trajectories). Figure 3 illustrates the three perinatal anxiety trajectory groups. There is a close fit between observed and predicted trajectories indicating a good model fit. The three anxiety trajectory groups with their 95% confidence limits are displayed in Figure 4.

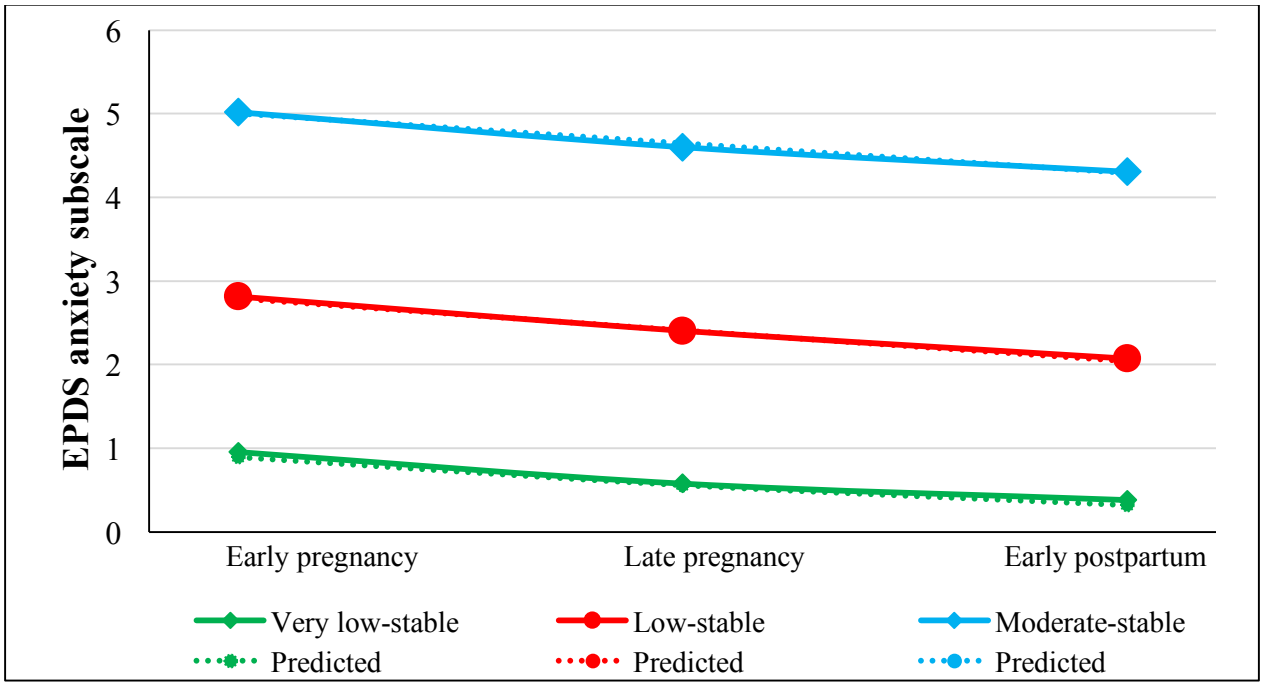


Figure 3. Observed versus predicted trajectory groups of perinatal anxiety symptoms of women from the FIP cohort study (n=615).

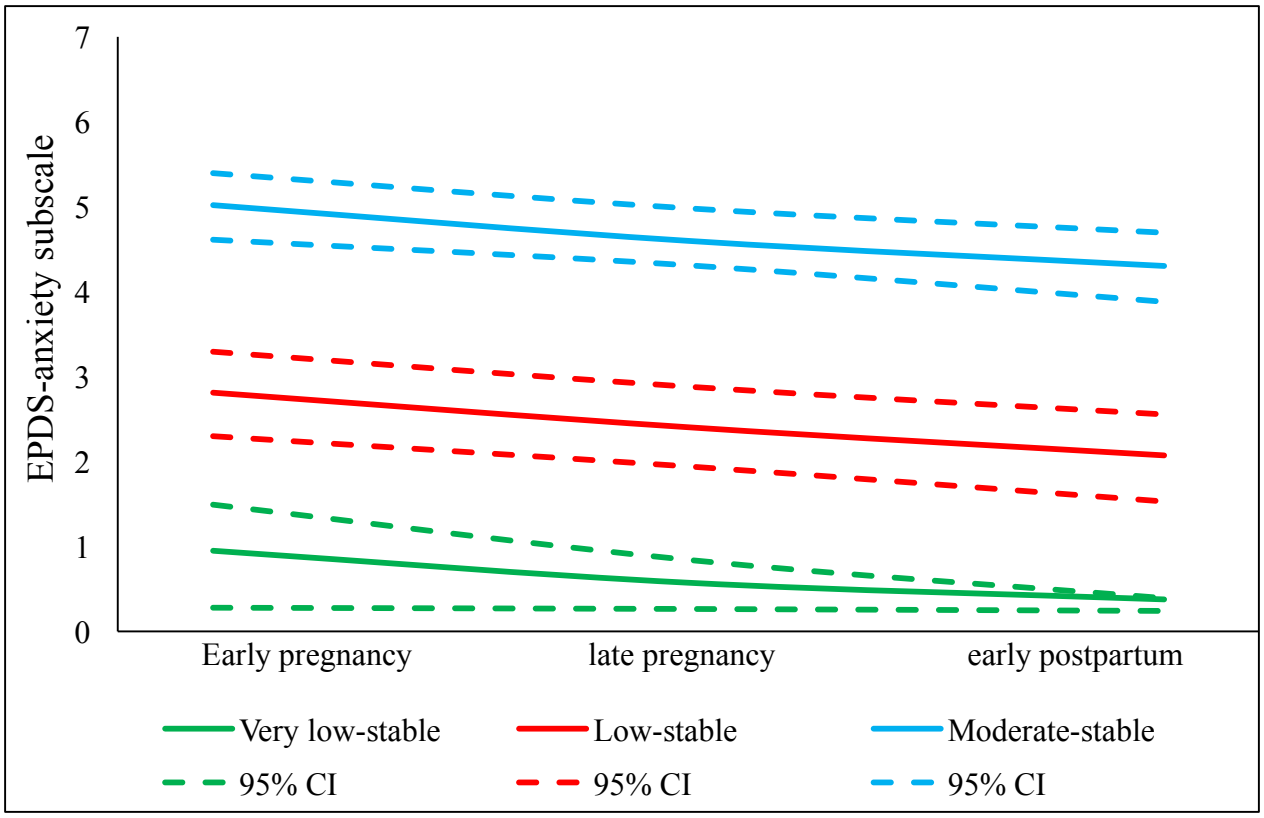


Figure 4. trajectory groups of perinatal anxiety symptoms of women from the FIP cohort study (n=615). Very low-stable (11%), Low-stable (56%), and Moderate-stable (34%).

The average posterior probability ranged from 0.83 for the very low and low groups to 0.87 for the moderate group (mean=0.84), indicating a very good model fit. In addition, the model showed a close correspondence between the estimated group probability versus proportion of sample assigned to each group, based on the maximum posterior probability assignment rule and high odds of correct group classification, as well as narrow confidence intervals of group membership probabilities (refer to Table 8).

Table 8. *Diagnostic statistics for judging model selection for trajectories of perinatal anxiety.*

Group	Average posterior probability	Proportion of sample assigned to group	Estimated group probability	odds of correct classification	CI for group membership probability
iI	0.83	0.09	0.11	41.40	0.07-0.14
2	0.83	0.61	0.56	3.89	0.52-0.59
3	0.87	0.30	0.34	13.10	0.29-0.39

The three anxiety trajectory groups were "very low-stable" (8.9%), which is composed of women whose level of anxiety symptoms were steadily very low over the period of follow-up. The largest anxiety trajectory group "Low-stable" (60.7%) included women whose anxiety symptoms were relatively stable but higher than those of the very low-stable trajectory group. The third trajectory group "Moderate-stable" consisted of women with moderate to high anxiety symptoms across pregnancy and early postpartum period (30.4%). These women had anxiety symptoms that probably met clinical significance. Mean values of EPDS-A scores by time and anxiety trajectory are summarized in Table 9.

Table 9. *EPDS-A scores [Mean (SD)] by time and trajectories of perinatal anxiety.*

	Time of assessment		
	Early pregnancy	Late pregnancy	Early postpartum
Very low	0.62 (0.80)	0.41 (0.60)	0.19 (0.44)
Low	2.82 (1.53)	2.36 (1.34)	2.05 (1.45)
Moderate	5.26 (1.50)	4.88 (1.50)	4.59 (1.69)

Note: EPDS-A, 3-item anxiety subscale; SD, standard deviation. The numbers of women in each trajectory are: very low (n=55), low (n=373), moderate (n=187).

4.3.3. Multinomial regression.

Perinatal depression trajectory groups. Univariate analyses were conducted for depression trajectories using the low-stable trajectory as a reference. Table 1 illustrates maternal characteristics by depression trajectories, as well as *p*-values resulted from univariate analyses.

After backward elimination, five significant predictors of perinatal depressive trajectories were identified including stress level, relationship satisfaction, past depression, mother's age, and ethnicity (refer to Table 10). Women assigned to the higher depressive symptom trajectories experienced significantly more stress than women assigned to the low-stable trajectory (moderate-stable: aOR=2.49, $p<0.001$; postpartum: aOR=2.73, $p=0.03$; antepartum: aOR=10.52, $p<0.001$). Moreover, women assigned to trajectories with moderate-high depressive symptoms were significantly more often to report past depression than women assigned to the low-stable trajectory group (moderate: aOR=2.66, $p<0.001$, antepartum: aOR=11.02, $p<0.001$). Being unsatisfied with the relationship with the partner increased the risk of being assigned to the antepartum trajectory group (aOR=6.74, $p<0.001$), but not for the moderate-stable or the postpartum groups. Compared to the low-stable trajectory group, the probability of being

assigned to the postpartum group increased if women were younger than 25 years (aOR=5.30, $p<0.001$). Though, this association was not significant for the moderate-stable or the antepartum groups. Women in the antepartum trajectory group were more likely to be non-Caucasian compared to the low-stable trajectory group (aOR=4.89, $p=0.003$).

Table 10. *Sociodemographic, psychosocial, and behavioral predictors of the identified latent trajectory groups for the perinatal depressive symptom based on the multivariate multinomial regression model.*

	Moderate-stable		Postpartum		Antepartum	
Variables	aOR	95% CI	aOR	95% CI	aOR	95% CI
Ethnicity: non-Caucasian	1.68	0.98-2.87	2.05	0.67-6.29	**4.89****	1.74-13.78
Mother's age	1.47	0.86-2.52	**5.30*****	2.00-14.03	2.17	0.67-6.12
Past depression: yes	**2.66*****	1.79-3.94	1.51	0.58-3.98	**11.02*****	3.40-35.69
Stress level: high	**2.49*****	1.70-3.64	**2.73***	1.08-6.87	**10.52*****	2.89-38.26
Relationship dissatisfaction	1.88	0.99-3.58	1.24	0.31-4.98	**6.74*****	2.43-18.70

Notes: Reference group is the low-stable trajectory group; aOR: adjusted odds ratio, CI: confidence interval; *$p<0.05$. **$p<0.01$. ***$p<0.001$; N=605 because of the missing data in covariates.

Expanding the trajectory model by introducing these predictors allowed us to calculate group membership probabilities for women with distinctive profiles of risk factors. For a non-Caucasian woman, whose age is less than 25, and who is not satisfied in her relationship with the partner, has high stress levels, and has a history of depression, the probability of being in the antepartum trajectory group is above 0.5, whereas the probability of membership to the low-stable trajectory group is very small (0.05). The probability of membership to the moderate-stable trajectory group for women with the same risk profile is 0.45. On the other hand, for a Caucasian woman whose age is 25 years or more, and who is satisfied in her relationship, has low stress levels, and has never experienced depression in the past, the probability of membership to the low-stable trajectory group is almost 0.90 but, the probability of membership to the antepartum trajectory group is only 0.0002.

Perinatal anxiety trajectory groups. Univariate analyses were also conducted for anxiety trajectories using the very low-stable trajectory group as a reference (refer to Table 1 for maternal characteristics by anxiety trajectory and univariate analyses results). After backward elimination

method, three significant covariates of perinatal anxiety trajectory groups were identified including stress level, past depression, and income (see Table 11). Women with a high level of stress were more likely to belong to the low-stable or the moderate-stable anxiety trajectory groups, compared to the very low-stable trajectory group (aOR= 3.90, 6.73; p=0.003, <0.001 respectively). A history of depression was associated with increased odds of belonging to the moderate-stable anxiety trajectory group compared the very low-stable group (aOR=4.44, p<0.001) but not for the low-stable group. There was no significant difference between either the moderate-stable or the low-stable trajectory groups and the very low-stable group as to income. However, women assigned to the moderate-stable trajectory group had significantly lower income that women in the low-stable trajectory group (OR ranged from 1.48 to 2.92, p<0.01).

Table 11. *Sociodemographic, psychosocial, and behavioral predictors of the identified latent trajectory groups for perinatal anxiety symptom based on the multivariate multinomial regression model.*

	Low-stable		Moderate-stable	
Variables	aOR	95% CI	aOR	95% CI
Income				
<$20,000/social assistance	0.82	0.26-2.56	2.39	0.74-7.76
$20,000 - $40,000	1.22	0.50-2.95	1.80	0.69-4.72
$40,000 - $60,000	0.80	0.39-1.64	1.66	0.75-3.68
Past depression: yes	1.67	0.75-3.74	**4.44*** **	1.94-10.26
Stress level: high	**3.90** **	1.60-9.52	**6.73*** **	2.67-16.99

Notes: The reference group is the very low-stable trajectory group; aOR, adjusted odds ratio; CI, confidence interval; *p<0.05. **p<0.01. ***p<0.001; Income was significant for the moderate-stable group versus the low-stable group; N=596 because of the missing data in the covariates.

Expanding the trajectory model by introducing these predictors allowed us to calculate group membership probabilities for women with distinctive profiles of risk factors. For a woman who is financially disadvantaged, and who has high stress levels and a history of depression, the probability of membership to the moderate-stable anxiety trajectory group is almost 0.5, whereas the probability of membership to the very low-stable trajectory group is small (0.10). On the other hand, for a woman who is financially better off, and who has low stress levels and no history of depression, the probability of membership to either the very low-stable or low-stable trajectory groups is above 0.90 but, the probability of membership to the moderate-stable trajectory group is only 0.09.

4.4. Discussion

We identified four latent trajectory groups for perinatal depressive symptoms and three latent trajectory groups for perinatal anxiety symptoms among women from early pregnancy to early postpartum. The largest trajectory group of depression "the low-stable group" included women with minimal depressive symptoms throughout the follow-up period. Studies report about three-quarters of women will experience no symptoms of perinatal depression (Mora et al., 2009; Sutter-Dallay et al., 2012), whereas only 50% of our sample fit this trajectory group. This could be related to the use of different screening tools for depression in these studies, and the use of different analytical approach by Mora and colleagues (Mora et al., 2009). Another large group of women (42.3%) reported a moderate and stable level of depressive symptoms that were below the clinical cutoff point but were well above the mean scores of women in the low-stable trajectory group. This is comparable to the mild depressive symptoms trajectory group identified by Bayrampour et al., and Kuo et al., (percentages of women belonged to this trajectory group were 51% and 42% respectively); both studies also used the EPDS to assess for depressive symptoms (Bayrampour et al., 2016; Kuo et al., 2014).

A distinguishing feature of this study is that measures in early and late pregnancy and early postpartum were included, which increases our understanding of the evolution of perinatal depressive and anxiety symptoms. And allowed us to identify two trajectory groups of high depressive symptoms that showed a significant variation over time, a postpartum trajectory group (3.6%) and a larger antepartum trajectory group (4.6%). In the present study, women in the antepartum trajectory showed some relief of their symptom severity postpartum, whereas depressive symptoms of women in postpartum trajectory group soared after birth, which is in keeping with results of other researchers (Bayrampour et al., 2016; Mora et al., 2009; Sutter-Dallay et al., 2012). Women in both groups had more severe symptoms than those of the moderate-stable and low-stable trajectory groups. Mean EPDS scores for women in postpartum and antepartum depression trajectory groups were well above the cutoff point of probable depression (Cox et al., 1987), which was not the case in Bayrampour's study who also used EPDS tool to measure depressive symptoms and found the mean EPDS scores of women in the antepartum trajectory and postpartum trajectory were both below 10, the cutoff point in the community setting (Bayrampour et al., 2016).

The antepartum and postpartum depressive trajectory groups were smaller than those identified in similar studies (Bayrampour et al., 2016; Mora et al., 2009; Sutter-Dallay et al., 2012). The antepartum group accounted for 21% of women in Sutter-Dallay's study and around 10% in Bayrampour's study (Bayrampour et al., 2016; Sutter-Dallay et al., 2012), while around 10% of women in the studies by Mora et al., and Bayrampour et al. belonged to the postpartum group (Bayrampour et al., 2016; Mora et al., 2009). Nonetheless, caution should be exercised when comparing different studies as sample sizes and period of follow-up were different, and some used different depression screening tools. Other studies showed larger proportions of women with high depressive symptom trajectories, which could be understandable as our sample included women who were relatively at low risk of developing depression, based on their sociodemographic profiles (Christensen et al., 2011; Gross et al., 2009; Mora et al., 2009). Overall, our results are in keeping with previous research that modeled perinatal depression trajectories; however, we found a variation of the severity of depressive symptoms rather than chronic depression across the perinatal period, whereas comparable studies identified trajectories of chronic depressive symptoms (Bayrampour et al., 2016; Kuo et al., 2014; Mora et al., 2009; Sutter-Dallay et al., 2012).

We identified three anxiety trajectory groups, while Bayrampour et al., found five trajectory groups and Kuo et al., concluded four trajectory groups of perinatal anxiety (Bayrampour et al., 2016; Kuo et al., 2014). This could be related to different sample sizes and participant characteristics. We conclude that almost 70% of women will experience very low or low anxiety symptoms throughout the perinatal period, which is comparable to other research (Bayrampour et al., 2016; Kuo et al., 2014). Almost 33% of our sample had possible clinically significant perinatal anxiety symptoms, which corresponds to the 24% prevalence rate of antenatal anxiety reported by others (Grant et al., 2008; Sutter-Dallay et al., 2004). There was a clear lack of fluctuation of anxiety symptoms across the perinatal period, relative to depressive trajectory groups, an observation that contradicts what Bayrampour and colleagues noted (Bayrampour et al., 2016). Women in the moderate-stable anxiety trajectory group who had probably a clinically significant anxiety did not show improvement of their symptoms postpartum, which contradict results of previous works that suggest improvement of anxiety symptoms postpartum (Agrati et al., 2015; Figueiredo & Conde, 2011; Madigan et al., 2014). Perhaps, with an extended follow-up to late postpartum, an improvement in anxiety symptoms could have been seen in our study.

The two major risk factors for trajectory groups with high symptoms of perinatal depressive and anxiety were the level of stress and history of depression. A history of depression was a major predictor of antepartum and moderate-stable depressive trajectory groups and the moderate-stable anxiety trajectory group, which is in keeping with the literature that documented past depression as one of the most significant predictors of perinatal depression (Lancaster et al., 2010; O'Hara & Swain, 1996). Stress was the only factor that consistently predicted trajectory groups with moderate to high depressive and anxiety symptoms, regardless of variation over time, Therefore, our results supported the premise that women with high perinatal depressive and/or anxiety symptoms were also coping with high stress levels (Leigh & Milgrom, 2008; Manuel et al., 2012).

In the present study, relationship satisfaction also appears to play a protective role against high levels of perinatal depressive symptoms, but not for anxiety symptoms. Although social support was significantly associated with high depressive trajectory groups in univariate analyses, it was no longer significant in multivariate analysis, which is inconsistent with the findings of Bayrampour and colleagues (2016) who concluded that low social support was a major antenatal predictor of high depressive and anxiety trajectory groups.

A variety of sociodemographic factors have been documented as significant predictors of perinatal depression and anxiety (J H Goodman, Chenausky, & Freeman, 2014; C. A. Lancaster et al., 2010; Nakku et al., 2006; L. Wang et al., 2011). However, we found few sociodemographic factors were significant in multivariate analyses. Though, the effect of sociodemographic predictors may have been underestimated in this low-risk sample. While a systematic review reports inconsistent findings of the effect of ethnicity/race on the risk of antenatal depression (Lancaster et al., 2010), being an immigrant or indigenous woman has been associated with increased risk of maternal depression at it was in our sample (Ganann et al., 2012; Roy, 2014). Young maternal age predicted the postpartum depressive trajectory group, which is in line with Bayrampour's study (Bayrampour et al., 2016). Despite the lack of research studies that looked at risk factors for perinatal anxiety (J H Goodman et al., 2014), income has been documented as a significant predictor of perinatal anxiety as it was in our study (Britton, 2008).

4.4.1. Strengths and limitations. Major strengths of the current study are the relatively large sample size, the longitudinal nature and the repeated assessments of participants, the significant proportion of participants who completed all assessments, the inclusion of the first

half of pregnancy in the follow-up, and the use of validated screening tools for perinatal depression and anxiety symptoms. Our findings should be interpreted in light of several study limitations. First, the study participants in our sample tended to be from low-risk group, and thus the generalizability of our results may be limited. Second, although the attrition was minimal in our study, the selective dropout of socially disadvantaged women, who are at higher risk of perinatal depression and anxiety, may have led to the underrating of the severity of these disorders, and the underestimation of the strength of association between maternal characteristics and perinatal depressive and anxiety trajectories. Third, the small number of women who belonged to the antepartum and postpartum depressive trajectories may have also impacted the significance and magnitude of association with maternal risk factors. We only included baseline predictors, which may have change over time. However, our primary focus is to identify risk factors that present early in pregnancy to allow for early targeted preventative measures towards women at high risk. Lastly, although the validated screening tools were used in this study are well-established, our analysis focused on self-reported symptoms of depression and anxiety rather than diagnoses of depression and anxiety disorders, which may also have limited our study.

4.4.2. Conclusion. This study adds to the important literature about distinct trajectories of perinatal depressive and anxiety symptoms. Whereas most women will not have any depressive or anxiety symptoms during the perinatal period, some women will experience these symptoms with varying degrees of severity and progress over time. The growing evidence of the heterogeneity of perinatal depressive and anxiety symptoms shows a need for screening from early pregnancy to the postpartum to help recognize women at high risk of depression or anxiety. Screening for psychosocial factors, including levels of stress and history of depression will allow clinicians to identify women at increased risk of developing perinatal depression and/or anxiety (Britton, 2008; Lancaster et al., 2010; O'Hara & Swain, 1996). This is particularly true during pregnancy and around birth, which can be major transitional periods in a woman's life. Early preventative and treatment interventions directed towards women at risk of developing high and/or persistent symptoms may alter the progress of these symptoms across the perinatal period.

Further research is recommended to examine the evolution of maternal mood disorders, specifically depressive and anxiety symptoms pre-conceptually and beyond the postpartum period as well as their trajectory impact on child development and health outcomes.

Chapter 5: Transition

In Chapter 4, distinct latent trajectory groups of the depressive and anxiety symptoms over the course of pregnancy and early postpartum were identified. As well, we have found maternal characteristics that are significantly associated with the identified latent trajectory groups. In Chapter 4, we focused on the period from pregnancy to early postpartum, as it is a unique period of time for the woman, who are prone to potentially drastic hormonal, physiological, and emotional changes. As well, the sample size in this study is mostly complete during the first three follow-up times. The FIP study in fact followed up the study participants from early pregnancy to the five years postpartum with five follow-ups in total, but the drop-out rate is high at the last two follow ups. Despite the challenges of dealing with incomplete data, one advantage of the latent trajectory analysis procedure is that it was extended to account for missing data due to participants' attrition (Haviland et al., 2011). In addition, identification of the latent trajectory groups over a longer follow up time, i.e. early pregnancy to five years postpartum, will give us a more comprehensive understanding of the depressive and anxiety symptoms evolvement pattern. Therefore, in Chapter 6, a second manuscript is presented to investigate the latent trajectory groups of maternal depressive and anxiety symptoms beyond the perinatal period (from pregnancy up to 5 years postpartum) and assess the associations of the latent group memberships with the antenatal predictors.

Chapter 6: Manuscript 2

This manuscript is prepared to be submitted to the *Journal of Affective Disorders*. The first author, Asma Ahmed, reviewed the relevant literature to do the analysis, analyzed the data using the appropriate statistical analytical procedure, interpreted the results, and drafted the manuscript.

Latent Trajectory Groups of Maternal Depressive and Anxiety Symptoms from Pregnancy to Five Years Postpartum and their Antenatal Predictors

Asma Ahmed, Cindy Feng, Angela Bowen, and Nazeem Muhajarine
University of Saskatchewan

Abstract

Background: There is evidence that depression and anxiety disorders do have distinct groups of symptom trajectories, which are associated with some factors that may vary among groups. Studying these mental health trajectories is highly relevant during major life transitions, such as pregnancy and childbirth. The aim of the study is to identify subgroups of individuals who exhibit distinct longitudinal trajectory patterns of depressive and anxiety disorders from pregnancy to five years postpartum and the antenatal predictors associated with these groups.

Methods: The study uses a longitudinal data collected from 615 women in Saskatchewan from pregnancy to five years postpartum (Feelings in Pregnancy and Motherhood (FIP) longitudinal study). The semiparametric group-based modeling strategy was used to identify maternal depressive and anxiety trajectory groups. Multinomial logit models were used to predict the effect of various maternal characteristics on these trajectory groups.

Results: Four trajectory groups of maternal depressive symptoms were identified: low-stable (35%); moderate-stable (54%); moderate-increasing (5%); and high-decreasing (6%). Significant risk factors for the moderate-stable group relative to the low-stable group were non-Caucasian ethnicity [aOR 1.80, 95% CI (1.02-3.17)], past depression [aOR 2.83, 95% CI (1.82-4.41)], and high stress level [aOR 3.16, 95% CI (2.08-4.81)]. Significant risk factors for the moderate-increasing group relative to the low-stable group were non-Caucasian ethnicity [aOR 2.95, 95% CI (1.10-7.91)], past depression [aOR 4.89, 95% CI (2.15-11.15)] and high stress level [aOR 3.99, 95% CI (1.77-8.99)]. Significant risk factors for the high-decreasing group relative to the low-stable group were non-Caucasian ethnicity [aOR 5.78, 95% CI (2.24-14.92)], past depression [aOR 9.04, 95% CI (3.57-22.89)], high stress level [aOR 21.67, 95% CI (6.92-67.89)], and smoking [aOR 4.79, 95% CI (1.68-13.66)]. Three trajectory groups of maternal anxiety symptoms were identified: very low-stable (13%); low-stable (58%); and moderate-stable (29%). The significant risk factor for the low-stable group relative to the very low-stable group was a high stress level [aOR 2.83, 95% CI (1.45-5.51)]. Significant risk factors for the moderate-stable group relative to the very low-stable group were low income [aOR ranged from 2.99 to 9.11, $p<0.01$] past depression [aOR 5.61, 95% CI (2.73-11.53)] and high stress level [aOR 4.53, 95% CI (2.20-9.33)].

Limitations: The low-risk sample and the high attrition rates, especially among high-risk women.

Conclusion: All significant risk factors can be identified during regular follow-up and thus, clinicians may be able to identify women at high risk. Women with these characteristics are potential candidates for early interventions that may alter the progress of their mental symptoms and ameliorate the effects on the child and family.
Keywords: Longitudinal trajectories, maternal depression, maternal anxiety, mood disorders, risk factors.

6.1. Introduction

Depression and anxiety disorders are highly prevalent among childbearing women, with rates as high as 30% (Britton, 2008; Wang, Wu, Anderson, & Florence, 2011). Maternal depression and anxiety are associated with poor health outcomes for the woman and her entire family (Buist, Gotman, & Yonkers, 2011; Letourneau et al., 2012). These symptoms beyond the perinatal period may have serious implications for the child's developmental and psychological outcomes (Fihrer, McMahon, & Taylor, 2009; Turney, 2012). Moreover, chronic depression affects long-term health, with increased psychiatric morbidity (most notably more frequent and severe depressions) as well as physical and cognitive decline (Goveas et al., 2014).

There is a growing evidence that maternal depressive and anxiety symptoms are a heterogeneous group of symptoms, highly diversified with their onset, course, duration, and severity (Campbell, Matestic, von Stauffenberg, Mohan, & Kirchner, 2007; Nandi, Beard, & Galea, 2009; van der Waerden et al., 2015). In their systematic review, Nandi and colleagues looked at population-based studies of depression and anxiety trajectories, of the 29 studies retrieved, eight were on adults, and only one of those was on mothers of young children (Nandi et al., 2009). They concluded that research in this area is still in its infancy; nonetheless, they found studies which confirms that depression and anxiety disorders have distinct groups of symptom trajectories, and these trajectories are associated with risk factors that may vary between groups (Nandi et al., 2009). Recognizing the heterogeneity of these common disorders may help to identify modifiable risk factors that are linked to certain trajectory groups, which may help to develop targeted preventative measures, as well as treatment interventions (Nandi et al., 2009). Early interventions, psychosocial and psychological interventions in particular, directed towards women at high risk have been documented to reduce their risks of developing major depression (Dennis & Hodnett, 2007).

A significant amount of literature on trajectories of maternal depression has examined the period between late pregnancy up to one to two years postpartum (Bayrampour, Tomfohr, & Tough, 2016; Kuo, Chen, & Tzeng, 2014; Sutter-Dallay, Cosnefroy, Glatigny-Dallay, Verdoux, & Rascle, 2012); however, there is a growing evidence that maternal depressive symptoms may exist well beyond the perinatal period (Essex, Klein, Miech, & Smider, 2001; Goodman, 2007). Studies that examined these symptoms past the perinatal period mostly identified between 4-6

trajectory groups (Campbell et al., 2007; Luoma, Korhonen, Salmelin, Helminen, & Tamminen, 2015; van der Waerden et al., 2015).

Among studies conducted in European countries, van der Waerden and colleagues in France identified five depression trajectories among women followed between pregnancy to five years postpartum (van der Waerden et al., 2015). A study in the US by Campbell et al., (2007) assessed 1,261 women for depressive symptoms from one month to seven years of giving birth and identified six trajectory groups of maternal depressive symptoms. Eighty-eight percent of women in van der Waerden's study had no or mild symptoms, and about 45% of women had low symptoms in the later study (van der Waerden et al., 2015). Both studies identified a moderate symptom group and a chronic high symptom group. van der Waerden et al., (2015) further identified a small group with high symptoms only during pregnancy, and another small group with symptoms only between the third and fifth year postpartum, whereas Campbell et al., (2007) concluded a moderate increasing, a high decreasing, and an intermittent group. Another European study followed mothers for a longer period. Luoma et al., (2015) followed 329 women in Finland for depression from pregnancy to the 17th birthday of the index child. They identified groups with low symptoms, moderate symptoms, high symptoms, and a small group with a fluctuating pattern of symptoms over time (Luoma et al., 2015).

Although maternal depression often coexists with anxiety (Goodman, 2007; Merikangas, Lieb, Wittchen, & Avenevoli, 2003), maternal depression and anxiety symptoms are two separate entities as to their clinical presentation and course (Hranov, 2007; Nandi et al., 2009). Anxiety disorders are highly prevalent among the general population (Kessler et al., 1994), but little is known about maternal anxiety symptoms, and research on maternal anxiety trajectories is particularly scarce. Among the few studies that examined maternal anxiety trajectories is a recent study conducted in Canada that identified five trajectories of anxiety symptoms during perinatal period among a community sample of 1,445 women (Bayrampour et al., 2016). These trajectories were classified as minimal, mild, antepartum, postpartum, and chronic; however, the follow-up was limited to one year postpartum. A study in Taiwan identified four anxiety trajectories during the perinatal period, namely low symptoms, mild symptoms, high symptoms, and very high symptoms (Kuo et al., 2014). This study was limited by the small sample size, the short time of follow-up (pregnancy to six months postpartum), and the limited generalizability as the data were only taken from women who had undergone elective cesarean sections. Thus, it is essential to

explore further trajectories of anxiety symptoms during motherhood beyond the first year of giving birth, and the risk factors associated with these trajectories.

The literature mostly examined correlates of maternal depression and anxiety (Beck, 2001; Britton, 2008; Lancaster et al., 2010; O'Hara & Swain, 1996). However, maternal characteristics that are associated with maternal depressive and anxiety trajectories have received little attention in the literature; thus, there remains a paucity of research that links longitudinal trajectories of maternal depression and anxiety to socio-demographic and psychosocial predictors. This is particularly important as some risk factors may be associated with certain subgroups of women with maternal depression or anxiety, which would allow for targeted interventions.

Results of these studies enhance our understanding of the evolution of maternal depressive and anxiety symptoms over time, and they provide evidence for the existence of longitudinal trajectories of maternal depression and anxiety. However, these findings may depend on the study population and length of follow-up. The experiences of women in the US or Europe may differ from those of women in other parts of the world. Furthermore, starting the assessment at late pregnancy or postpartum in many of these studies may have a remarkable effect on the shape of these trajectories, given the high prevalence of depressive and anxiety symptoms during pregnancy.

This study aims to answer the following questions: 1. What are the distinct trajectory patterns for maternal depressive symptoms from pregnancy to five years postpartum and what are the antenatal predictors associated with these trajectory groups? and 2. What are the distinct trajectory patterns for maternal anxiety symptoms from pregnancy to five years postpartum, and what are the antenatal predictors associated with these trajectory groups?

6.2. Methods

6.2.1. Sample. This study is a secondary analysis of data from the Feelings in Pregnancy and Motherhood Study (FIP), and the subsequent Feelings in Pregnancy and Motherhood Study: Child and Maternal Outcomes (A. Bowen, Bowen, Butt, Rahman, & Muhajarine, 2012; Rahman, Bowen, & Muhajarine, 2014). FIP is a longitudinal epidemiological study of maternal depression and associated factors over a five-year period. Six hundred and forty-six women in their early pregnancy were recruited from the community. Eligibility criteria for participating in the study included a) being within the first 20 weeks of pregnancy; b) speak English; and c) residing in one

of two regional health authorities in Saskatchewan (Saskatoon Health Region and Five Hills Health Region). Data were collected via face-to-face individual interviews from pregnancy up to five years of giving birth. Women were assessed twice during pregnancy; early (at 17.4 +/- 4.9 weeks of gestation), and late (at 30.6 +/- 2.7weeks of gestation), one time at early postpartum (at 4.2 +/-2.1 weeks postpartum), and at the child's third and fifth birthday.

From the FIP data, information on maternal depression and anxiety was available from 646 women at time 1 (early pregnancy), 598 women at time 2 (late pregnancy), 586 women at time 3 (early postpartum), 337 women at time 4 (36 months postpartum), and from 309 women at time 5 (60 months postpartum). For this study, we excluded cases with more than three missing values, and thus our sample included 615 participants.

Attrition rates were the highest among young, non-Caucasian, financially disadvantaged, unemployed, and low educated women who had an unplanned pregnancy, were unsatisfied with their relationship with the partner, had low levels of social support, and who were more likely to be smokers and to have a history of depression. Previous missing data analyses on the FIP data also showed that two patterns of missing data are significantly related with depression scores; missing EPDS scores at the 36 and 60 postpartum, and missing data at early postpartum, 36 and 60 months postpartum (Rahman, Bowen, & Muhajarine, 2017). For using the data in our study, we obtained an ethical approval from the office of research Ethics at the University of Saskatchewan.

6.2.2. Measures

Perinatal depressive symptoms. The Edinburgh Postnatal Depression Scale (EPDS) was used to assess women for depressive symptoms (Cox et al., 1987). The EPDS is one of the most commonly validated screening tools for detection of perinatal depression (Cox et al., 1987). It is a 10-item self-rated questionnaire that takes less than five minutes to complete (Cox et al., 1987), and has a sensitivity of 59–100% and a specificity of 49–100% (The American College Of Obstetricians & Gynecologists, 2015). Responses to the EPDS questions are reported on a Likert scale from zero to three with a maximum score is 30, and women with scores higher 12 in research settings are very likely to be depressed (Cox et al., 1987).

Perinatal anxiety symptoms. The three-item anxiety subscale (EDPS-A) was used to screen for anxiety symptoms (Matthey, Fisher, et al., 2013). Bowen et al. have confirmed an EPDS anxiety subscale (Items 3–5) during pregnancy (Bowen et al., 2008), while Ross et al.,

confirmed the same factors in postpartum women (Ross et al., 2003). Responses to these three items are reported on a Likert scale from zero to three with a maximum scale is nine, and scores above four suggest probable anxiety (Matthey, Valenti, et al., 2013).

Sociodemographic factors. Participants reported a variety of sociodemographic characteristic at the first point of assessment, including age (either <25 years or ≥ 25 years old), marital status (married/cohabiting or non-partnered), ethnicity (Caucasian or non-Caucasian), education (below grade 12 or grade 12 and higher), employment (employed or not employed), income per a year (social assistance/<20,000$, 20,000$-40,000$, 40,000$-60,000$, and >60,000$), and parity (0 or ≥1)

Psychosocial factors.

Social support. Social support was measured by asking participants, "Do you have someone to turn to for emotional support?" if they responded yes, they were asked to indicate people who provide them with social support. Responses to these questions were combined into one variable that indicates the level of social support, with 0-1 support treated as low-level of support while two or more supports considered as high-level of support.

Stress. Women were asked to indicate sources of stress from a list of stressors, which included work, place of living, relationship with partner, being pregnant, the health of the baby, the birth of the baby, school, own health, and other stressors. Their responses were combined into one variable that indicates the level of stress each participant experienced. This variable was dichotomized as low stress level (0-2 stressors) or high stress level (two or more stressors).

Additionally, participants indicated whether the pregnancy was planned or not, and were asked to indicate the level of satisfaction (very satisfied or not) with their relationship with the partner, if they have one. Furthermore, participants reported any history of depression in the past.

Behavioral factors. Participants reported their smoking status (yes or no/quit), any alcohol consumption (yes or no/quit), or recreational drug use including marijuana (yes or no/quit), as well as their exercise level (regular or never/occasional).

6.2.3. Data Analysis.

Group-based trajectory models. The semiparametric, group-based approach for modeling developmental trajectories (Nagin, 2005) was used to identify trajectories of maternal depressive symptoms based on their total EPDS scores and anxiety symptoms based on their EPDS-A scores from early pregnancy to five years postpartum. Group-based trajectory model is an application of

finite mixture models, which assumes that the population is composed of a finite number of distinct groups that are clustered based on their symptom trajectories, either depressive or anxiety (Nagin & Odgers, 2010). It allows for the identification of clusters of individuals who follow a similar evolution of behavior, in this case depression or anxiety over time. The PROC TRAJ procedure in SAS was used to estimate group-based trajectories models (Jones & Nagin, 2007; Jones et al., 2001). One must first decide the appropriate data distribution before fitting a trajectory model. As was illustrated by Nagin (2005), censored normal distribution-based model (CNORM model) is used for psychometric scale data, which usually shows clustering of data at the scale's minimum and/or maximum. In our study, depression and anxiety tend to cluster at the minimum value, which can lead to a skewed distribution; therefore, we chose to use CNORM distribution.

A two-stage model selection strategy was used to find the optimum number of groups and shape of trajectories that best fit the data (Nagin, 2005). In the first stage, we started to test models that consisted of two groups with cubic degree polynomial, and then we increased the number of groups from two to six with trajectories that are all cubic, guided by information from previous literature (Bayrampour et al., 2016; Campbell et al., 2007; Cents et al., 2013; Gross et al., 2009; Kuo et al., 2014; Luoma et al., 2015; Skipstein et al., 2010; van der Waerden et al., 2015). Once the number of groups was identified based on model selection criteria (Bayesian Information Criterion (BIC), Bayes factor, and the probability of being the correct model), a backward elimination method was used to alter the order of trajectories. Non-significant cubic, quadratic, and linear terms were removed consecutively, and each model was retested to check the BIC value until all terms in the model were significant (linear, quadratic, and/or cubic). Theoretical considerations such as the expected number and shape of trajectories, as well as the interpretability of these trajectories were also considered (Campbell et al., 2007). To check whether the model fit the data well, several model diagnostics were used, including the average posterior probability of assignment, the odds of correct classification, the estimated group probability versus proportion of sample assigned to the group, and the confidence intervals for group membership probability.

Multinomial regression models. We fitted a multinomial regression model using group membership as the dependent variable to assess the effect of various maternal characteristics on the probability of belonging to a specific trajectory group compared to a reference group (Agresti

& Kateri, 2011; Nagin, 2005). Bivariate analyses were initially conducted to test for associations between maternal sociodemographic, psychosocial, and behavioral characteristics at baselines and the dependent variable which represented the trajectory group membership (depression or anxiety). Next, a multivariate multinomial regression model was built by including all variables that were statistically associated with the outcome variable ($p<0.25$) based on univariate analyses. Using backward elimination procedure, we excluded all independent variables that were insignificant ($p>0.05$) from the model. Once significant risk factors were identified, we repeated the analyses in the PROC TRAJ procedure, including the risk factors. These analyses will account for the participants' probabilities of membership to the other trajectories, and thus will consider the uncertainty of the assigned group membership (Nagin, 2005). All analyses were performed using SAS software version 9.4.

Missing data. Missing data is a very common problem in longitudinal studies Haviland et al., 2011)., and the FIP study is no exception. Due to the significant number of participants' attrition, especially during year three and year five of follow-up, we included the dropout statement extension in the PROC TRAJ SAS procedure to account for missing data due to participants' attrition (Haviland et al., 2011). Hence, dropout probability for each group and trajectory group probabilities after attrition were estimated. Afterward, we compared models with and without the dropout statement to check the magnitude of change in the trajectory shape parameter estimates, as well as group membership probabilities.

6.3. Results

Most of the participants were primiparous, Caucasian women living in a stable relationship with a relatively high socioeconomic status (see Table 12). Table 13 provides the mean and standard deviation of the EPDS and EPDS-A scores at each assessment. One hundred percent of the sample had completed the EPDS at least twice, and 96.3% had completed assessments at least three times.

Table 12. *Sociodemographic, psychosocial, and behavioral characteristics by perinatal depression and anxiety trajectories [n (%)].*

Maternal characteristics	Total (n=615)	Depression Trajectories				*p*
		Low-stable (n=215)	Moderate-stable (n=332)	Moderate-increasing (n=32)	High-decreasing (n=36)	
Mother's age						0.025
<25 years	96 (15.61)	27 (12.56)	50 (15.06)	8 (25.00)	11 (30.56)	
≥ 25 years	519 (84.39)	188 (87.44)	282 (84.94)	24 (75.00)	25 (69.44)	
Parity						0.438
0	327 (53.26)	121 (56.28)	171 (51.66)	19 (59.38)	16 (44.44)	
≥ 1	287 (46.74)	94 (43.72)	160 (48.34)	13 (40.63)	20 (55.56)	
Education						0.022
< grade 12	24 (3.91)	5 (2.34)	12 (3.61)	2 (6.25)	5 (13.89)	
≥ grade 12	590 (96.09)	209 (97.66)	320 (96.39)	30 (93.75)	31 (86.11)	
Ethnicity						0.004
Caucasian	522 (85.02)	193 (89.77)	280 (84.59)	25 (78.13)	24 (66.67)	
Non-Caucasian	92 (14.96)	22 (10.23)	51 (15.41)	7 (21.88)	12 (33.33)	
Marital status						0.001
Non-partnered	57 (9.27)	10 (4.65)	33 (9.94)	4 (12.50)	10 (27.78)	
Partnered	558 (90.73)	205 (95.35)	299 (90.06)	28 (87.50)	26 (72.22)	
Employment						0.001
Yes	487 (79.45)	185 (86.05)	259 (78.25)	22 (68.75)	21 (60.00)	
No	126 (20.55)	30 (13.95)	72 (21.75)	10 (31.25)	14 (40.00)	
Income						<0.001
< $20,000	75 (12.46)	14 (6.54)	40 (12.42)	5 (16.13)	16 (45.71)	
20-$40,000	109 (18.11)	33 (15.42)	64 (19.88)	8 (25.81)	4 (11.43)	
40-$60,000	129 (21.43)	41 (19.16)	76 (23.60)	6 (19.35)	6 (17.14)	
> $60,000	289 (48.01)	126 (58.88)	142 (44.10)	12 (38.71)	9 (25.71)	
Past depression						<0.001
Yes	217 (35.28)	35 (16.28)	136 (40.96)	18 (56.25)	28 (77.78)	
No	398 (64.72)	180 (83.72)	196 (59.04)	14 (43.75)	8 (22.22)	
Stress level						<0.001
Low (0-2)	362 (59.44)	170 (80.57)	174 (52.73)	14 (43.75)	4 (11.11)	
High (>2)	247 (40.56)	41 (19.43)	156 (47.27)	18 (56.25)	32 (88.89)	
Support level						0.043
Low (0-1)	104 (16.94)	25 (11.63)	63 (19.03)	6 (18.75)	10 (27.78)	
High (>1)	510 (83.06)	190 (88.37)	268 (80.97)	26 (81.25)	26 (72.22)	
Relationship satisfaction						<0.001
Not satisfied	75 (12.27)	14 (6.51)	38 (11.55)	6 (18.75)	17 (48.57)	
Satisfied	536 (87.73)	201 (93.49)	291 (88.45)	26 (81.25)	18 (51.43)	
Planned pregnancy						0.001

Maternal characteristics	Total (n=615)	Depression Trajectories: Low-stable (n=215)	Moderate-stable (n=332)	Moderate-increasing (n=32)	High-decreasing (n=36)	*p*
Yes	366 (59.51)	147 (68.37)	190 (57.23)	16 (50.00)	13 (36.11)	
No	249 (40.49)	68 (31.63)	142 (42.77)	16 (50.00)	23 (63.89)	
Smoking						<0.001
No or quit	548 (89.25)	203 (94.42)	293 (88.52)	27 (84.38)	25 (69.44)	
Yes	66 (10.75)	12 (5.58)	38 (11.48)	5 (15.63)	11 (30.56)	
Alcohol						0.321
No or quit	573 (93.17)	202 (93.95)	309 (93.07)	31 (96.88)	31 (86.11)	
Yes	42 (6.83)	13 (6.05)	23 (6.93)	1 (3.13)	5 (13.89)	
Drugs						0.310
No or quit	596 (97.07)	208 (97.20)	324 (97.59)	31 (96.88)	33 (91.67)	
Yes	18 (2.93)	6 (2.80)	8 (2.41)	1 (3.13)	3 (8.33)	
Exercise						0.103
Never or occasional	284 (46.18)	90 (41.86)	155 (46.69)	16 (50.00)	23 (63.89)	
Regular	331 (53.82)	125 (58.14)	177 (53.31)	16 (50.00)	13 (36.11)	

Maternal characteristics	Anxiety Trajectories: Very low-stable (n=80)	Low-stable (n=357)	Moderate-stable (n=178)	*p*
Mother's age				<0.001
<25 years	7 (8.75)	44 (12.32)	45 (25.28)	
≥25 years	73 (91.25)	313 (87.68)	133 (74.72)	
Parity				0.850
0	42 (52.50)	187 (52.53)	98 (55.06)	
≥1	38 (47.50)	169 (47.47)	80 (44.94)	
Education				0.147
< grade 12	1 (1.25)	12 (3.37)	11 (6.18)	
≥ grade 12	79 (98.75)	344 (96.63)	167 (93.82)	
Ethnicity				0.036
Caucasian	73 (91.25)	308 (86.27)	141 (79.66)	
Non-Caucasian	7 (8.75)	49 (13.73)	36 (20.34)	
Marital status				0.029
Non-partnered	4 (5.00)	28 (7.84)	25 (14.04)	
Partnered	76 (95.00)	329 (92.16)	153 (85.96)	
Employment				0.050
Yes	68 (85.00)	289 (81.18)	130 (73.45)	
No	12 (15.00)	67 (18.82)	47 (26.55)	
Income				<0.001
<$20,000	2 (2.50)	36 (10.26)	37 (21.64)	
20-$40,000	15 (18.75)	57 (16.24)	37 (21.64)	
40-$60,000	15 (18.75)	70 (19.94)	44 (25.73)	
>$60,000	48 (60.00)	188 (53.56)	53 (30.99)	

Maternal characteristics	Anxiety Trajectories			*p*
	Very low-stable (n=80)	Low-stable (n=357)	Moderate-stable (n=178)	
Past depression				<0.001
No	12 (15.00)	99 (27.73)	106 (59.55)	
Yes	68 (85.00)	258 (72.27)	72 (40.45)	
Stress level				<0.001
Low (0-2)	66 (84.62)	223 (62.99)	73 (41.24)	
High (>2)	12 (15.38)	131 (37.01)	104 (58.76)	
Support level				0.105
Low (0-1)	8 (10.00)	59 (16.57)	37 (20.79)	
High (>1)	72 (90.00)	297 (83.43)	141 (79.21)	
Relationship satisfaction				0.009
Not satisfied	7 (8.75)	35 (9.86)	33 (18.75)	
Satisfied	73 (91.25)	320 (90.14)	143 (81.25)	
Planned pregnancy				0.030
Yes	55 (68.75)	218 (61.06)	93 (52.25)	
No	25 (31.25)	139 (38.94)	85 (47.75)	
Smoking				0.011
No or quit	76 (95.00)	324 (90.76)	148 (83.62)	
Yes	4 (5.00)	33 (9.24)	29 (16.38)	
Alcohol				0.402
No or quit	77 (96.25)	329 (92.16)	167 (93.82)	
Yes	3 (3.75)	28 (7.84)	11 (6.18)	
Drugs				0.250
No or quit	80 (100)	343 (96.35)	173 (97.19))	
Yes	0.00 (0.00)	13 (3.65)	5 (2.81	
Exercise				
Never or occasional	33 (41.25)	160 (44.82)	91 (51.12)	0.248
Regular	47 (58.75)	197 (55.18)	87 (48.88)	

Notes: p is the p-value associated with results of univariate multinomial regression analyses.

Table 13. *Edinburgh Postnatal Depression Scale (EPDS) and 3-item Anxiety Scale (EPDS-A) at Each Assessment.*

	Time of assessment				
	Early Pregnancy (n=615)	Late Pregnancy (n=601)	Early Postpartum (n=592)	36 months postpartum (n=337)	60 months postpartum (n=308)
EPDS					
Mean (SD)	6.75 (4.45)	6.19 (4.32)	5.59 (4.14)	4.58 (3.85)	4.74 (3.76)
No. (%) depressed (EPDS>12)	63 (10.24)	47 (7.82)	33 (5.57)	18 (5.34)	13 (4.21)
EPDS-A					
Mean (SD)	3.36 (2.03)	2.95 (1.93)	2.63 (2.00)	2.17 (1.77)	2.33(1.81)
No. (%) anxious (EPDS-3>4)	190 (30.89)	134 (22.33)	106 (17.91)	34 (10.09)	40 (12.94)

Notes: SD, standard deviation; Range of EPDS score = 0–29; Range of EPDS-A scores = 0-9.

6.3.1. Maternal depression trajectory groups. Models with two to six groups were analyzed. The BIC score increased from the two-group to the four-group model, and then it started to decrease as further groups were added (see Table 14). The Bayes factor showed a strong evidence for the four-group model against the three-group and five-group model. Therefore, we chose the four-group model as the best fitting and most parsimonious model.

Table 14. *Model fit indices for maternal depression trajectories with 2-6 groups.*

Number of groups	BIC (n=2453)	Probability of being the correct model	BIC (n=615)	Probability of being the correct model
2	-7485.6	0.0000	-7474.5	0.0000
3	-7443.4	0.0157	-7426.8	0.0001
4	**-7439.3**	**0.9839**	**-7417.1**	**0.8909**
5	-7446.9	0.0005	-7419.2	0.1091
6	-7472.5	0.0000	-7439.3	0.0000

Notes: BIC, Bayesian information criterion; n=2453, the total number of assessments used in model estimation across persons and time; n=615, the number of individuals in the estimation sample.

Inspection of parameter estimates for the four-group model showed that only the constant and linear terms were significant for the low-stable and moderate-stable groups, whereas the cubic term was significant for the moderate-increasing and the high-decreasing (see Table 15).

Table 15. *Maternal depression trajectories parameter estimates (n=615).*

Group	Intercept	Linear	Quadratic	Cubic	Group membership probability
Model with dropout extension					
Low stable	3.73***	-0.36***	-	-	35.76%***
Moderate stable	7.95***	-0.55***	-	-	51.81%***
Moderate-increasing	14.62***	-10.13	5.09*	-0.64*	6.06%**
High-decreasing	7.28	15.19**	-7.63***	0.94***	6.37%***
Model without dropout extension					
Low stable	3.68***	-0.40***	-	-	32.98%***
Moderate stable	7.81***	-0.61***	-	-	51.14%**
Moderate-increasing	11.29***	-1.79	0.44	-0.02	11.05%***
High-decreasing	11.65**	8.34	-4.02	0.44	4.83%***

Notes: *P<0.05. **P<0.01. ***P<0.001

Figure 5 depicts the predicted and observed maternal depression groups, while Figure 6 shows the four maternal depression groups with 95% confidence limits. The average posterior probability ranged from 0.83 for the moderate-increasing group to 0.91 for the high-decreasing group (mean=0.86), indicating a very good model fit. In addition, the model met three other indicators of model adequacy; a close correspondence between the estimated group probability versus proportion of sample assigned to each group, based on the maximum posterior probability assignment rule; high odds of correct group classification relative to chance; and narrow confidence intervals for group membership probabilities (refer to Table 16).

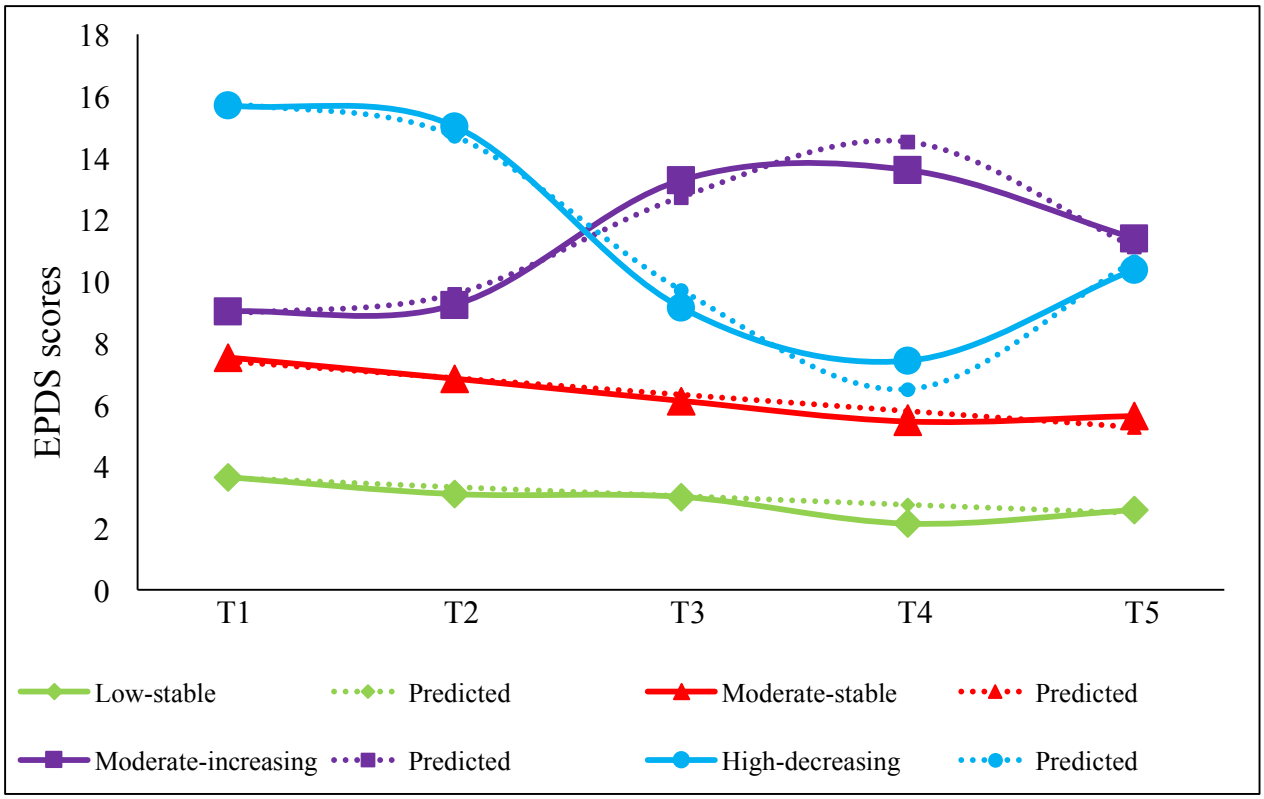


*Figure 5.*Observed versus predicted trajectory groups of maternal depression symptoms of women from the FIP cohort study (n=615).

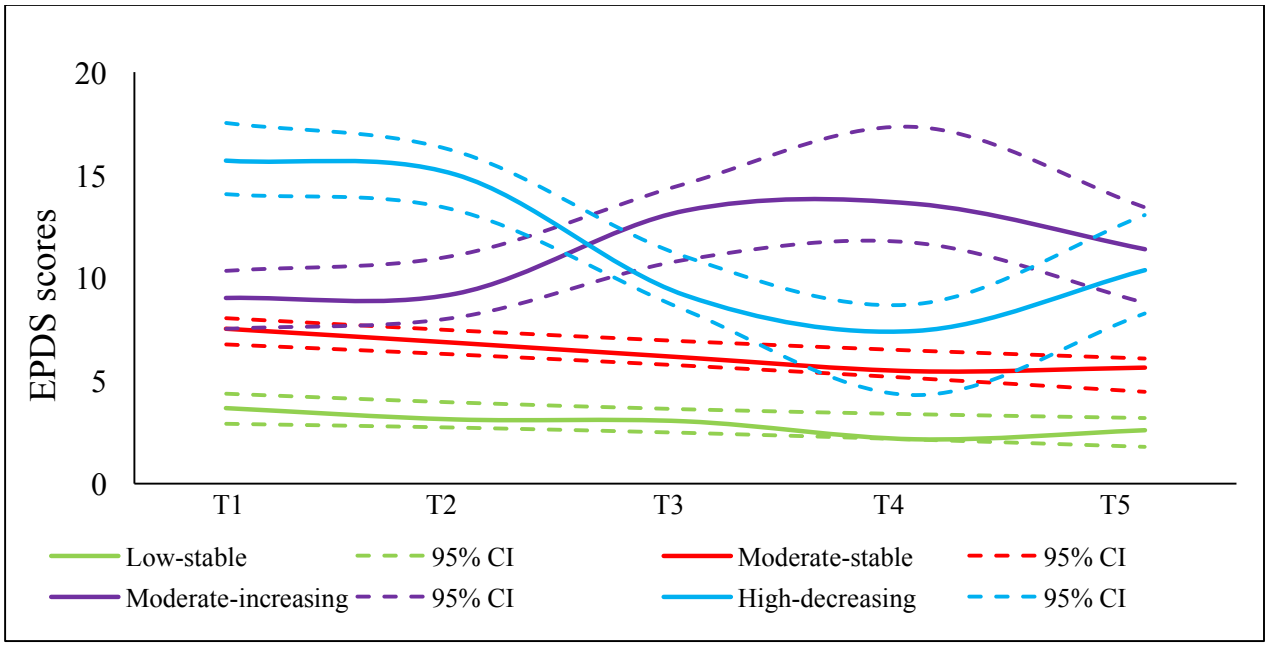


Figure 6. Trajectory groups of maternal depression symptoms of women from the FIP cohort study (n=615). Low-stable (35.76%), Moderate-stable (51.81%), Moderate-increasing (6.06%), and High-decreasing (6.37%).

Table 16. *Diagnostic statistics for judging model selection for trajectories of maternal depression.*

Group	Average posterior probability	Proportion of sample assigned to group	Estimated group probability	odds of correct classification	CI for group membership probability
1	0.84	0.35	0.36	9.43	0.29- 0.42
2	0.84	0.54	0.52	4.88	0.48-0.56
3	0.83	0.05	0.06	75.68	0.04- 0.08
4	0.91	0.06	0.06	148.62	0.05-0.08

The first depression group "low-stable" (35.0%) included women whose EPDS scores were consistently low throughout the follow-up period, and their mean EPDS ranged from 1.95 to 3.37. Women in the largest group "moderate-stable" (52.0%) reported a moderate level of depressive symptoms across the period of follow-up that minimally decreased over time. Their mean EPDS scores were consistently higher than those for women in the low-stable group (mean EPDS scores ranged from 5.74 to 7.07). More fluctuations were seen in the other two groups (moderate-increasing and high-decreasing), as evident from the significant cubic term for both groups. Depression scores for women assigned to the moderate-increasing group (5.2%) were slightly higher than those of the moderate-stable group during pregnancy. However, their EPDS scores increased significantly postpartum, reaching possibly clinically significant levels throughout the period between early postpartum and five years postpartum. On the other hand, women in the high-decreasing group (5.9%) experienced high levels of depressive symptoms during pregnancy, which started to improve gradually after giving birth, except for a slight increase between the third and fifth year of follow-up. Table 17 summarizes the mean and SD of EPDS scores for women in each depression group.

Table 17. *EPDS scores [Mean (SD)] by time and trajectories of maternal depression.*

	Time of assessment				
	Early pregnancy	Late Pregnancy	Early Postpartum	36 months postpartum	60 months postpartum
Low stable	3.37 (2.42)	2.82 (2.11)	2.76 (2.16)	1.95 (1.76)	2.42 (2.16)
Moderate stable	7.07 (3.36)	6.99 (2.98)	6.29 (3.17)	5.64 (3.34)	5.74 (3.17)
Moderate-increasing	9.09 (3.09)	9.59 (4.51)	14.06 (4.78)	14.00 (2.83)	11.70 (5.12)
High-decreasing	16.11 (4.71)	15.53 (4.51)	9.21 (5.05)	7.50 (3.40)	11.18 (3.66)

Notes: EPDS= Edinburgh Postnatal Depression Scale; the numbers of women in each trajectory are: Low-stable (n=215), Moderate-stable (n=332), Moderate-increasing (n=32), High-decreasing (n=36).

As to their dropout probabilities, for women in the moderate-stable and moderate-increasing depression groups, the dropout depended on EPDS level, as women with high EPDS scores were more likely to dropout more often. The dropout probabilities for the low-stable and high-decreasing group were independent of EPDS scores. However, the average dropout probabilities were the highest for the high-decreasing group at time 3 (early postpartum), and they ranged from 0.26 to 0.34 for that group. The moderate-increasing group also showed high dropout probabilities at time 3, 4, and 5, ranging from 0.21 to 0.36. The average dropout probabilities for maternal depression trajectory groups are illustrated in Figure 7.

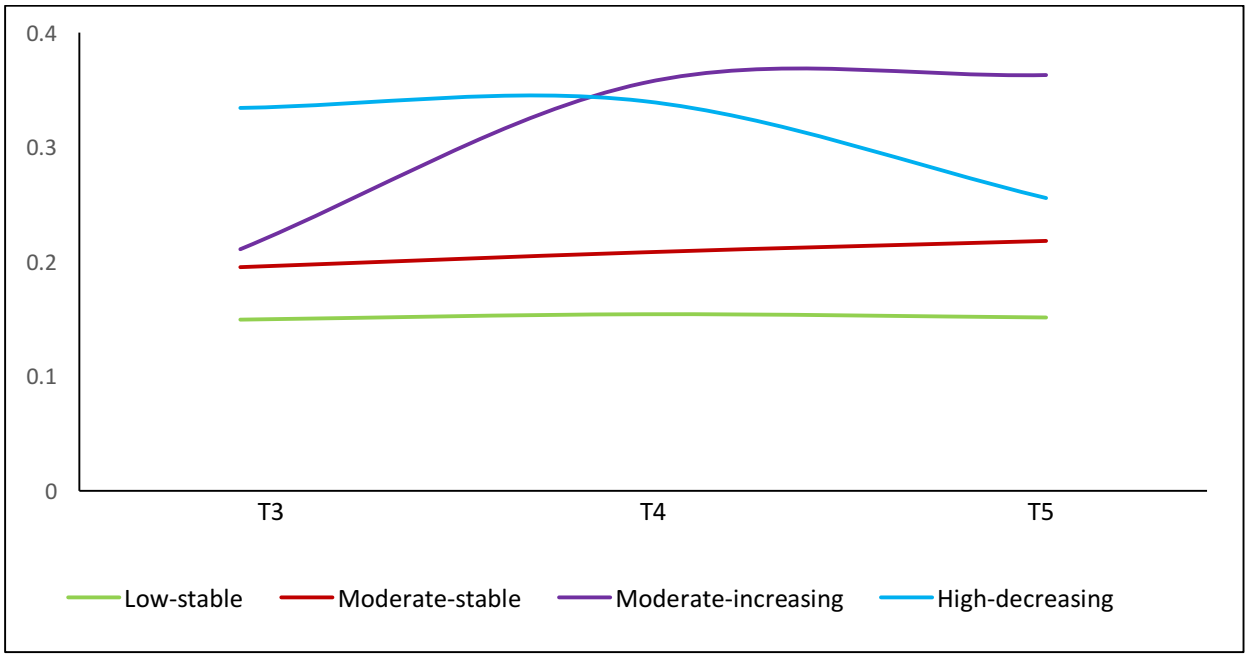


Figure 7. Dropout probability for maternal depression trajectory groups of women from the FIP cohort study (n=615).

Comparison of the model with and without the dropout extension revealed that parameter estimates for the low-stable and moderate-stable groups were almost identical between both models. However, trajectory shape parameter estimates for the other two groups were somewhat different, as intercept were similar but the estimates for the linear, quadratic, and cubic terms were different. A similar observation was noticed regarding group membership probabilities, as there was a considerable difference in group membership probabilities for the moderate-increasing and the high-decreasing groups calculated using models with and without dropout extension. Table 15 provides parameter estimates for the model with and without the dropout extension.

6.3.2. Maternal anxiety trajectory groups. To determine the best number of anxiety groups, we compared BIC values of the two-group to six-group models. The BIC score increased from the two-group model to the three-group model, but they started to decrease as further groups were added (refer to Table 18). The Bayes factor indicated a strong evidence for the three-group model against the two-group and the four-group model. Hence, we concluded the three-group model as the best fitting and most parsimonious model.

Table 18. *Model fit indices for maternal anxiety trajectories with 2-6 groups.*

Number of groups	BIC(n=2 453)	Probability of being the correct model	BIC (n=615)	Probability of being the correct model
2	-5645.8	0.0000	-5634.7	0.0000
3	**-5614.9**	**0.9999**	**-5598.3**	**0.9219**
4	-5624.5	0.0001	-5602.4	0.0167
5	-5628.7	0.0000	-5601.1	0.0613
6	-5644.6	0.0000	-5611.4	0.0000

Notes: BIC, Bayesian information criterion; n=2,453, the total number of assessments used in model estimation across persons and time; n=615, the number of individuals in the model estimation.

As to parameter estimates for the three-group model, the constant and linear terms were significant for all groups. However, the quadratic term was significant only for the first the very low-stable and low-stable groups (see Table 19). Figure 8 illustrates the three maternal anxiety groups, and figure 9 shows anxiety groups with their 95% confidence limits. The average posterior probability ranged from 0.87 for the low-stable and the moderate-stable groups to 0.88 for the very low-stable group (mean=0.87), indicating a very good model fit. Other model fit diagnostics also indicated a good model fit (Table 20).

Table 19. *Maternal anxiety trajectories parameter estimates (n=615).*

Group	Intercept	Linear	Quadratic	Cubic	Group membership probability
Model with dropout extension					
Very low-stable	1.64**	-1.11**	0.16*	-	13.71%***
Low-stable	3.69***	-0.83***	0.10***	-	56.12%***
Moderate-stable	5.43***	-0.34***	-	-	30.17%***
Model without dropout extension					
Very low-stable	1.76**	-1.15*	0.15	-	14.00%***
Low-stable	3.61***	-0.77***	0.09**	-	55.00%***
Moderate-stable	5.45***	-0.37***	-	-	30.98%***

Notes: *P<0.05. **P<0.01. ***P<0.001

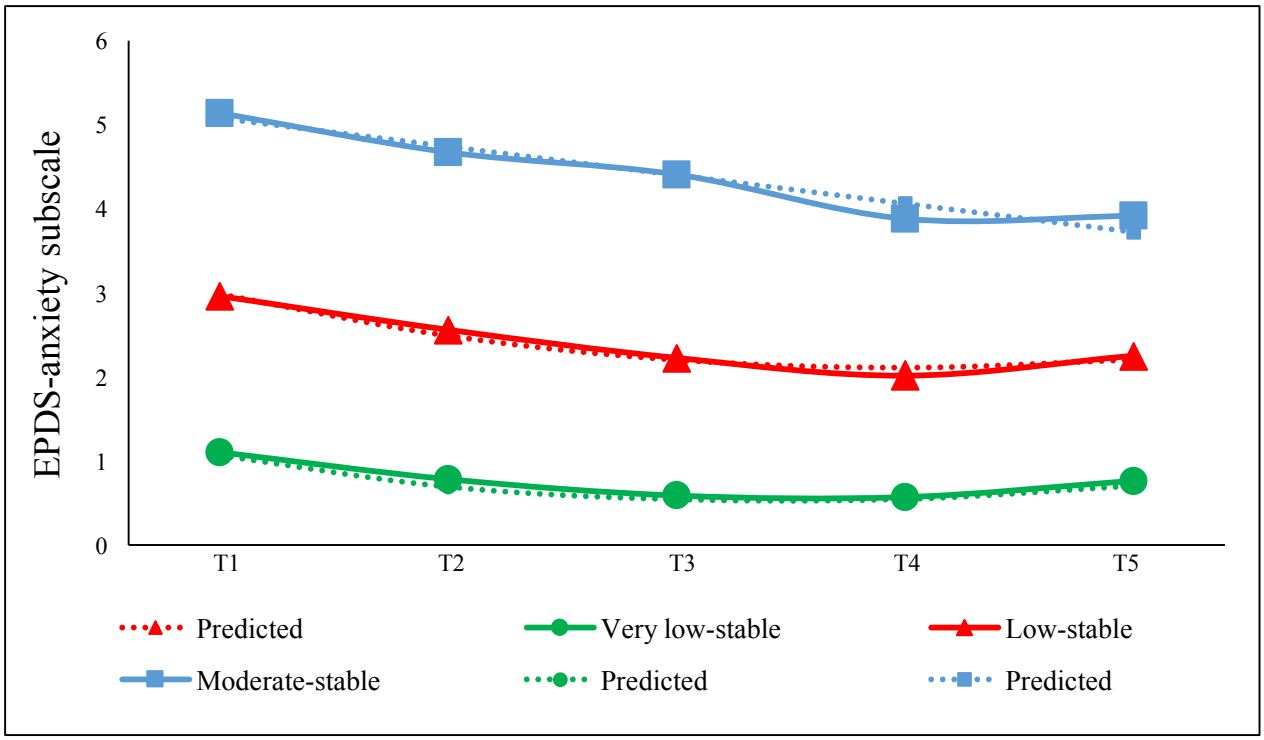


Figure 8. Observed versus predicted trajectory groups of maternal anxiety symptoms of women from the FIP cohort study (n=615).

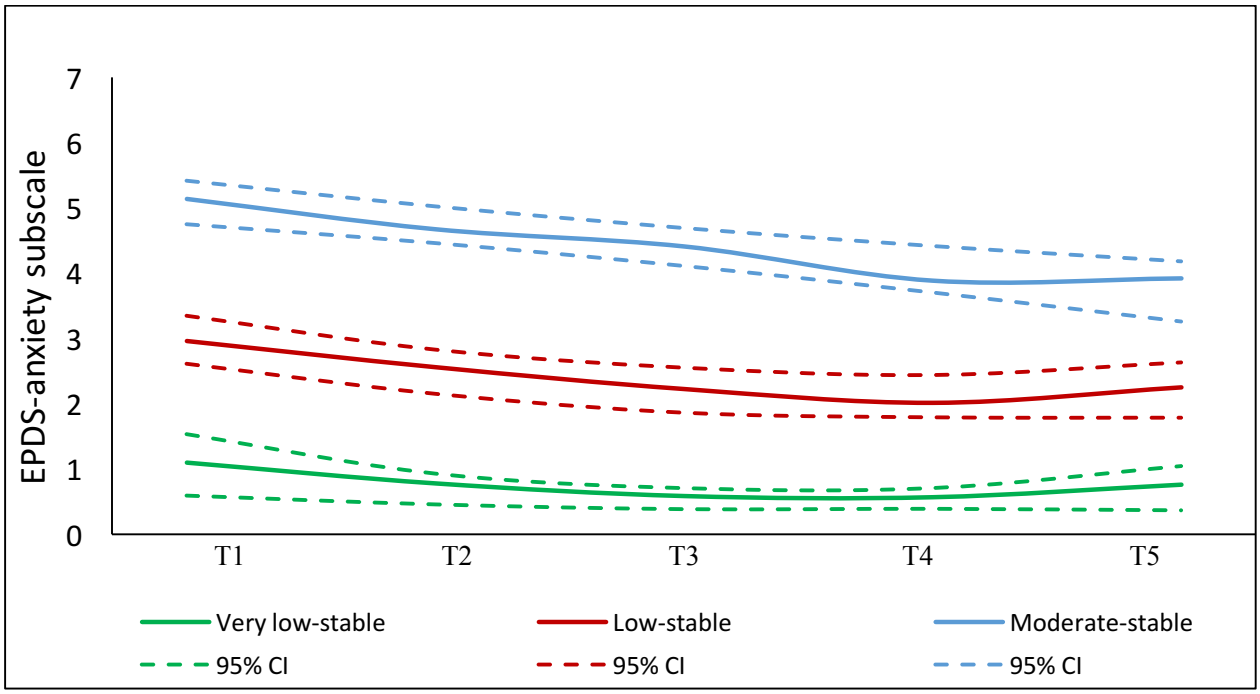


Figure 9. Trajectory groups of maternal anxiety symptoms of women from the FIP cohort study (n=615). Very low-stable (13.71%), Low-stable (56.12%), and Moderate-stable (30.17%).

Table 20. *Diagnostic statistics for judging model selection for trajectories of perinatal anxiety*.

Group	Average posterior probability	Proportion of sample assigned to group	Estimated group probability	odds of correct classification	CI for group membership probability
1	0.88	0.13	0.14	46.16	0.11-0.16
2	0.87	0.58	0.56	5.23	0.53-0.59
3	0.87	0.29	0.30	15.49	0.26-0.34

The first and smallest group "very low-stable" (13.0%) is composed of women whose anxiety symptoms were the lowest of the sample and were relatively stable over the whole period of follow-up. Their mean EPDS-A scores ranged from 0.48 to 0.99. More than half the sample (58.1%) belonged to the second group "low-stable", and their anxiety scores were fairly constant at levels that were higher than those of the very low-stable group. The third group "moderate-stable" included women with moderate to high anxiety scores throughout the period of follow-up, but with a slight decrease over time. Almost one-third of the sample fell into this group (29.0%), and their mean EPDS-A scores ranged from 4.02 to 5.30. Table 21 illustrates mean and SD of EPDS-A scores for women in each anxiety group.

Table 21. *EPDS-A scores [Mean (SD)] by time and trajectories of maternal anxiety.*

	Time of assessment				
Trajectory	Early pregnancy	Late Pregnancy	Early Postpartum	36 months postpartum	60 months postpartum
Very low-stable	0.99 (1.07)	0.76 (0.90)	0.50 (0.76)	0.48 (0.82)	0.73 (1.00)
Low-stable	2.93 (1.55)	2.50 (1.41)	2.22 (1.53)	2.02 (1.32)	2.28 (1.45)
Moderate-stable	5.30 (1.49)	4.84 (1.53)	4.55 (1.72)	4.10 (1.70)	4.02 (1.84)

Notes: EPDS-A, 3-item anxiety subscale; SD, standard deviation. The numbers of women in each trajectory are: very low-stable (n=80), low-stable (n=357), moderate-stable (n=178).

Regarding the dropout probabilities, for the low-stable anxiety groups, dropout probability depended on EPDS-A level, as women with high EPDS-A scores were more likely to dropout. The dropout probability was independent on EPDS-A scores for the other two anxiety groups. The average dropout probabilities were the highest for the moderate-stable group at time 3, 4, and 5, ranging from 0.25 to 0.26. The average dropout probabilities for each anxiety groups are illustrated in Figure 10.

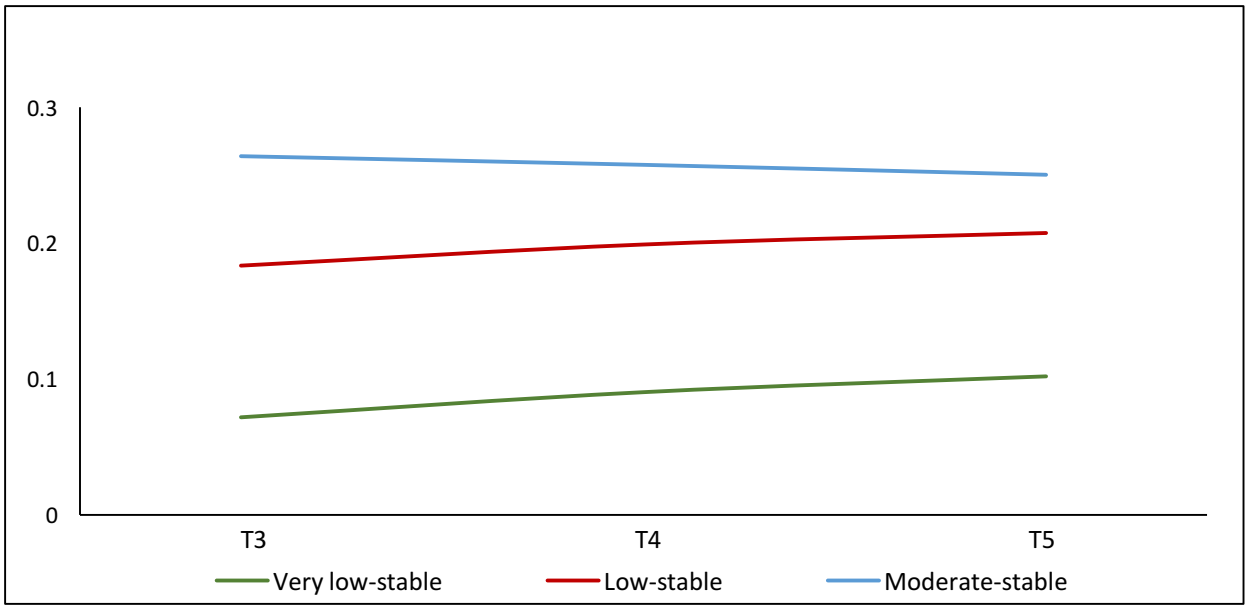


*Figure 10.*Dropout probability for maternal anxiety trajectory groups of women from the FIP cohort study (n=615).

Comparison of the model with and without dropout extension revealed that trajectory shape parameter estimates for both models were almost identical. Similarly, group membership probabilities calculated using models with and without dropout were minimally different. Table 8 provides parameter estimates for the model with and without dropout extension.

6.3.3. Multinomial regression. Members of the maternal depression and anxiety groups differed by sociodemographic, psychosocial, and behavioral maternal characteristics at baseline. For depression trajectory groups, risk factors of membership in the moderate-stable compared with the low-stable group included a history of depression (aOR 2.83, $p<0.001$), high stress level (aOR 3.16, $p<0.001$), and non-Caucasian ethnicity (1.80, $p=0.041$). Compared to the low-stable group, membership in the moderate-increasing group was associated with a history of depression, high stress level, and non-Caucasian ethnicity (aOR 4.89, 3.99, and 2.95, $p=0.032$, <0.001, and <0.001 respectively). For the high-decreasing group, significant associations compared to the low-stable group included a history of depression (aOR 9.04, $p<0.001$), high stress level (aOR 21.67, $p<0.001$), being a smoker (aOR 4.79, $p=0.003$), and non-Caucasian ethnicity (5.78, $p<0.001$) (see Table 22).

Table 22. *Sociodemographic, psychosocial and behavioral predictors of the latent trajectory groups for the maternal depressive symptoms based on the multivariate multinomial regression model.*

	Moderate-stable		Moderate-increasing		High-decreasing	
Determinants	aOR	95% CI	aOR	95% CI	aOR	95% CI
Ethnicity: non-Caucasian	1.80*	1.02-3.17	2.95*	1.10-7.91	5.78***	2.24-14.92
Past depression: yes	2.83***	1.82-4.41	4.89***	2.15-11.15	9.04***	3.57-22.89
Stress level: high	3.16***	2.08-4.81	3.99***	1.77-8.99	21.67***	6.92-67.89
Smoking: yes	1.80	0.88-3.70	2.33	0.72-7.50	4.79**	1.68-13.66

Notes: Low-stable group is the reference group; aOR, adjusted odds ratio, CI, confidence interval; *p<0.05. **p<0.01. ***p<0.001; N=607 because of the missing data in the covariates.

Expanding the trajectory model by introducing these predictors allowed us to calculate group membership probabilities for women with distinctive profiles of risk factors. For a non-Caucasian woman who smokes during pregnancy, and who has high stress levels and a history of depression, the probability of being in the moderate-stable trajectory group is 0.45 and the probability of being in the high-decreasing trajectory group is above 0.27, whereas the probability of membership to the low-stable trajectory group is very small (0.03). On the other hand, for a Caucasian woman who does not smoke, and who has low stress levels and has never experienced depression in the past, the probability of membership to the low-stable trajectory group is 0.83 but, the probability of membership to either the moderate-increasing or high-decreasing trajectory group is very small.

Results of multinomial regression for anxiety groups showed that compared to the very low-stable group, the only variable that was associated with the low-stable group is the high stress level (aOR 2.83, p=0.002). On the other hand, high stress level (aOR 4.53, p<0.001), any history of depression (aOR 5.61, p<0.001), and income (40-$60,000 versus >$60,000, aOR 2.99, p=0.004; $20,000 versus >$60,000, aOR 9.11, p=0.004) were associated with the moderate-stable group, relative to the very low-stable group (refer to Table 23).

Table 23. *Sociodemographic, psychosocial and behavioral predictors of latent trajectory groups of the perinatal anxiety symptom based on the multivariate multinomial regression model.*

	Low-stable		**Moderate-stable**	
	aOR	95% CI	aOR	95% CI
Income				
<$20,000/assistance	3.39	0.78-14.80	**9.11****	2.00-41.47
$20,000 – $40,000	0.84	0.43-1.64	1.72	0.80-3.71
$40,000 - $60,000	1.29	0.66-2.51	**2.99****	1.40-6.37
Past depression: yes	1.66	0.84-3.26	**5.61*****	2.73-11.53
Stress level: high	**2.83****	1.45-5.51	**4.53*****	2.20-9.33

Notes: Very low-stable group is the reference group; aOR, adjusted odds ratio, CI, confidence interval; *p<0.05. **p<0.01. ***p<0.001; N=596 because of the missing data in the covariates.

Expanding the trajectory model by introducing these predictors allowed us to calculate group membership probabilities for women with distinctive profiles of risk factors. For a woman who is financially disadvantaged, and who has high stress levels and a history of depression, the probability of membership to the moderate-stable anxiety trajectory group is almost 0.72, whereas the probability of membership to the very low-stable trajectory group is small (0.01). On the other hand, for a woman who is financially privileged, and who has low stress levels and no history of depression, the probability of membership to either the very low-stable or low-stable trajectory groups is almost 0.90 but, the probability of membership to the moderate-stable trajectory group is only 0.11.

6.4. Discussion

Group-based trajectory modeling was used to understand the evolution of maternal depressive and anxiety symptoms from pregnancy to five years postpartum among the study women. We identified four trajectory groups of maternal depression and three trajectory groups of maternal anxiety. The four depression trajectory groups were low-stable (35.0%), moderate-stable (54.0%), moderate-increasing (5.2%), and high-decreasing (5.9%). Whereas the first two groups showed a steady pattern of depressive symptoms over time, the other two groups (moderate-increasing and high-decreasing) displayed a more fluctuating progress over time. Women who belonged to the low-stable and moderate-stable had EPDS scores that were probably below the cutoff point of clinical significance throughout the period of follow-up. This is consistent with results of previous studies, as each of van der Waerden et al., (2015), Campbell et al., (2007), and Luoma et al., (2015) identified trajectory groups with no symptoms, low

symptoms, and/or moderate symptoms of depression that were relatively stable across the period of follow-up, and had the biggest proportion of participants.

Similar to our high-decreasing group, van der Waerden and colleagues identified a prenatal group (5%) with high symptoms during pregnancy that decreased after giving birth and increased again between three and five years postpartum (van der Waerden et al., 2015), whereas Luoma and Campbell did not identify a similar group (Campbell et al., 2007; Luoma et al., 2015). The slight increase in EPDS scores seen between years three and five of the follow-up could possibly be related to a subsequent pregnancy, although this information was not readily available from the FIP data. Campbell et al. (2007), concluded a moderate-increasing group with a very close pattern to our moderate-increasing group, and with an almost identical proportion of participants (6.2%). Each of these studies concluded a small group of high symptoms that were relatively stable over time (also referred to by some as chronic). However, it seems that groups with high depressive symptoms in our study were more fluctuant over time. It is worth mentioning that among those studies, only Luoma et al., (2015) used the EPDS to assess for the depressive symptom, whereas both van der Waerden and Campbell used the Center for Epidemiological Studies-Depression (CES-D) questionnaire. Furthermore, the period of follow-up varied considerably among these studies, thus, caution is required when comparing our results to these studies.

We also identified three anxiety trajectory groups, very low-stable (13.0%), low-stable (58.1%), and moderate-stable (29.0%). Bayrampour et al. (2016), documented five trajectory groups of maternal anxiety among 1,445 women in Canada, who were followed from pregnancy to one year postpartum (Bayrampour et al., 2016). Around 70% of the women in our sample experienced very low or low anxiety symptoms throughout the period of follow-up, which is comparable to Bayrampour's results (Bayrampour et al., 2016). Almost a third of our sample had moderate-high anxiety symptoms that were stable across pregnancy to five years postpartum, whereas Bayrampour et al. concluded two groups of high anxiety symptoms that varied over time; antepartum and postpartum groups. They also concluded a very small group (1.5%) with chronic anxiety symptoms (Bayrampour et al., 2016). Women in the moderate-stable anxiety trajectory in the current study showed minimal improvement of their symptoms over time, which contradict results of previous works that suggest improvement of anxiety symptoms postpartum (Agrati et al., 2015; Figueiredo & Conde, 2011; Madigan et al., 2014).

In the present study, various maternal characteristics were significantly associated with maternal depression and/or anxiety trajectory groups. For both maternal depression and anxiety, high stress level and a history of depression consistently predicted groups with moderate to high depressive or anxiety symptoms, regardless of the symptoms' variation over time. Moreover, as the severity of symptom increases, the magnitude of the impact of these two risk factors increases, suggesting a dose-response relationship. It appeared that women who have experienced depression in the past are vulnerable to both depression and anxiety during pregnancy, postpartum, as well as to persistent symptoms that extend well beyond the perinatal period. In fact, the recurrence of these mental illnesses around childbirth could be explainable, as the perinatal period is a stressful period in the woman's life, with many changes over a short period, including the baby birth, and the need to adapt to new parenting responsibilities (Britton, 2008). This is in keeping with the literature which indicated that a history of depression significantly increases the risk of developing antepartum and postpartum depression and anxiety (Beck, 2001; Britton, 2008; Lancaster et al., 2010; O'Hara & Swain, 1996) and there is evidence to support that various sources of stress are associated with increased risk of maternal depression and/or anxiety (Britton, 2008; Leigh & Milgrom, 2008; Manuel, Martinson, Bledsoe-Mansori, & Bellamy, 2012). The present study concluded that stress is a major determinant of women's mental health, especially during childbearing period, which is also consistent with van der Waerden and Bayrampour results (Bayrampour et al., 2016; van der Waerden et al., 2015).

As to the sociodemographic correlates of maternal depression and/or anxiety trajectory groups, ethnicity emerged as significant predictors of trajectory groups with high depressive symptoms. Non-Caucasian women were more likely to belong to the moderate-stable or the high-decreasing groups, relative to the low-stable group, which is consistent to what van der Waerden and Campbell concluded (Campbell et al., 2007; van der Waerden et al., 2015). Low income has been documented to increase the risk of both depression and anxiety (Britton, 2008; O'Hara & Swain, 1996), as it was for the trajectory group with moderate anxiety symptoms but, this factor was not significant for any depression trajectory group. This could be related to the small size of trajectory groups with high depressive symptoms, and the small number of low-income participants in our sample. The only behavioral factor that significantly predicted high depressive symptoms groups was smoking. Le Strat and colleagues examined a cross-sectional data from 1524 pregnant and postpartum women in the USA and found that using substances (including

alcohol, illicit drugs, and cigarettes) is associated with maternal depression (Le Strat, Dubertret, & Le Foll, 2011).

6.4.1. Strengths and limitations. Key strengths of the present study are the large sample size, the longitudinal nature and the repeated assessments of participants, and the use of validated screening tools for maternal depression and anxiety. Another distinguishing feature of this study is that the first and the second halves of pregnancy were included in the follow-up, which was essential to understand the evolution of depressive and anxiety symptoms across the antepartum period; a period with increased risk of both disorders. Limitations of this study include the high attrition rates, the use of self-administered questionnaires to measure depressive and anxiety symptoms, and the fact that participants who dropped out of the study could be at high risk of being depressed or anxious, which may have led to the underestimation of the severity of these disorders, and may have affected the significance and magnitude of association with maternal risk factors. We only included baseline predictors, which may have change over time. However, our primary focus is to identify risk factors that present early in pregnancy to allow for early targeted preventative measures towards women at high risk. Our sample included women who may be at low risk of maternal mental disorders, and thus the generalizability of our results may be limited. Last, although the validated screening tools were used in this study are well-established, our analysis focused on self-reported symptoms of depression and anxiety rather than diagnoses of depression and anxiety disorders, which may also have limited our study.

6.4.2. Conclusion. The current study provides evidence of distinct trajectory groups of maternal depression and anxiety that evolve over time. We also identified maternal characteristics associated with these trajectory groups that are present before or during early pregnancy. The findings suggest that early prevention of depressive and anxiety symptoms should specifically target pregnant women with a history of depression and high levels of stress. Further research is recommended to examine the evolution of depressive and anxiety symptoms among different populations, particularly high-risk populations. Also, examining the impact of different maternal mental health trajectory groups on the children's developmental and/or psychological outcomes would enhance our understanding of the relationship between maternal mental health and child health outcomes.

Chapter 7: Discussion

This thesis sought to understand the heterogeneity of the depressive and anxiety symptoms among mothers by identifying subgroups of women who exhibit distinct longitudinal trajectory patterns of depressive and anxiety disorders from pregnancy to postpartum and beyond and the risk factors associated with these trajectories. Previous research supports that maternal depressive and anxiety symptoms do have distinct groups of symptom trajectories, and these trajectories are associated with some factors that may vary among groups.

7.1. Summary of the main findings

In this thesis, we used a semiparametric group-based modeling approach to identify distinct trajectory groups of depressive and anxiety symptoms from early pregnancy to early postpartum, as well as from early pregnancy to five years postpartum.

In the first study which examined trajectories of depression and anxiety from early pregnancy to early postpartum, the largest trajectory group of depression "the low-stable group" included women with minimal depressive symptoms throughout the follow-up period. Studies report about three-quarters of women will experience no symptoms of perinatal depression (Mora et al., 2009; Sutter-Dallay et al., 2012), whereas only 50% of our sample fit this trajectory group. This could be related to the use of different screening tools for depression in these studies, and the use of different analytical approach by Mora and colleagues (Mora et al., 2009). Another large group of women (42.3%) reported a moderate and stable level of depressive symptoms that were below the clinical cutoff point but were well above the mean scores of women in the low-stable trajectory group. This is comparable to the mild depressive symptoms trajectory group identified by Bayrampour et al., and Kuo et al., (percentages of women belonged to this trajectory group were 51% and 42% respectively); both studies also used the EPDS to assess for depressive symptoms (Bayrampour et al., 2016; Kuo et al., 2014).

Around eight percent of our sample showed a significant variation of their depressive symptoms from pregnancy to early postpartum, and giving birth seems to be the major time point when these changes occur. These women belonged to either the postpartum trajectory (3.6%) or the antepartum trajectory (4.6%). Depressive symptoms of women in postpartum trajectory increased considerably after birth, whereas women in the antepartum trajectory showed some

relief of their symptoms severity after giving birth, an observation that is in keeping with results of other researchers (Bayrampour et al., 2016; Mora et al., 2009; Sutter-Dallay et al., 2012). Women in both trajectories had symptoms more severe than those of the moderate-stable and low-stable trajectories, as their mean EPDS scores well above the cutoff point of clinically significant depression (between 16 and 17 during pregnancy for the antepartum trajectory and almost 18 during early postpartum for the postpartum trajectory).

In the second study, the period of follow-up was extended to five years postpartum. The identified four depression trajectories in the second study were low-stable (35.0%), moderate-stable (54.0%), moderate-increasing (5.2%), and high-decreasing (5.9%). Whereas the first two trajectories showed a steady pattern of depressive symptoms over time, the other two trajectories (moderate-increasing and high-decreasing) displayed a more fluctuating progress over time. Women who belonged to the low-stable and moderate-stable trajectories had EPDS scores that were below the cutoff point of clinical significance throughout the period of follow-up. This is consistent with results of previous studies of maternal depression trajectories. Each of van der Waerden et al., Campbell et al., and Luoma et al., identified trajectory groups with no symptoms, low symptoms, and/or moderate symptoms of depression that were relatively stable across the period of follow-up, and had the biggest proportions of participants (Campbell et al., 2007; Luoma et al., 2015; van der Waerden et al., 2015).

Similar to our high-decreasing trajectory, van der Waerden and colleagues identified a prenatal trajectory (5%) with high symptoms during pregnancy that decreased after giving birth and increased again between the third and fifth years postpartum (van der Waerden et al., 2015). The slight increase in EPDS scores seen between the year three and five of the follow-up could possibly be related to a subsequent pregnancy, although this information was not readily available from the FIP data. Campbell et al. concluded a moderate-increasing trajectory with a very close pattern to our moderate-increasing trajectory and with an almost identical proportion of participants (6.2%) (Campbell et al., 2007). Each of these studies concluded a small trajectory of high symptoms that were relatively stable over time (some of them called it chronic) (Campbell et al., 2007; Cents et al., 2013; Luoma et al., 2015; van der Waerden et al., 2015). However, no such a trajectory was identified in our study.

Overall, our results are in line with previous research studies that modeled trajectories of maternal depressive symptoms. However, our findings did not support that depressive symptoms

persist from pregnancy to postpartum and beyond. Rather, the present thesis showed a variation of the severity of depressive symptoms across the perinatal period and beyond. We also did not find a trajectory of chronic perinatal depressive symptoms, as was identified by other researchers (Bayrampour et al., 2016; Luoma et al., 2015; Mora et al., 2009; Sutter-Dallay et al., 2012; van der Waerden et al., 2015). It is worth mentioning that previous studies used different assessment tools to measure depressive symptoms, and the period of follow-up varied considerably among these studies (Bayrampour et al., 2016; Campbell et al., 2007; Cents et al., 2013; Luoma et al., 2015; van der Waerden et al., 2015). Thus, caution should be exercised when comparing results of these studies to ours.

We also identified three anxiety trajectories across two different periods of follow-up; early pregnancy to early postpartum, and early pregnancy to five years postpartum, and these trajectories were very similar in both of our studies. Almost 70% of women belonged to either the very low-stable or low-stable trajectories, which is comparable to previous research (Bayrampour et al., 2016; Kuo et al., 2014). Approximately one third of our sample belonged to the moderate-stable trajectory, with possibly clinically significant anxiety symptoms across the period of follow-up that showed minimal improvement over time. This contradicted result of previous works that suggest improvement of anxiety symptoms postpartum (Agrati et al., 2015; Figueiredo & Conde, 2011; Madigan et al., 2014). Bayrampour et al., documented five trajectory groups of maternal anxiety among 1445 women in Canada, who were followed from pregnancy to one year postpartum (Bayrampour et al., 2016). Whereas the trajectory with moderate anxiety symptoms in the present thesis was relatively steady over time, Bayrampour et al., concluded two trajectories of moderate/high anxiety symptoms that varied over time; antepartum and postpartum trajectories. They also concluded a very small trajectory (1.5%) with chronic anxiety symptoms. Skipstein and colleagues conducted two different studies in which they examined trajectories of depressive and anxiety symptoms among almost a thousand women in Norway followed from 18 months postpartum to 14.5 years afterward (Skipstein et al., 2012; Skipstein et al., 2010). In their earlier study, Skipstein and colleagues identified six trajectories of depressive and anxiety symptoms; no symptoms, low level symptoms, moderate level symptoms, chronic high level symptoms, and low-rising (Skipstein et al., 2010). Although their trajectory groups represented both depression and anxiety, the moderate symptom trajectory (32%) in their two studies was

very similar to the moderate-stable anxiety trajectory identified in the current study (Skipstein et al., 2012; Skipstein et al., 2010).

Various sociodemographic, psychosocial, and behavioral factors are associated with maternal depression and/or anxiety trajectories (Bayrampour et al., 2016; Christensen et al., 2011; Mora et al., 2009; Sutter-Dallay et al., 2012; van der Waerden et al., 2015). In this thesis, psychosocial factors emerged as the most prominent risk factors of maternal depression and anxiety trajectories, and the higher the severity of depressive and anxiety symptoms, the more evident the impact of these psychosocial factors, which suggests a dose-response relationship. The two major risk factors for trajectories with high symptoms of maternal depressive and anxiety were the level of stress and the history of depression, regardless of the length of the follow-up period.

Past depression is a well-documented risk factor for maternal depression that probably has the biggest impact on increasing the risk of maternal depression (Lancaster et al., 2010; O'Hara & Swain, 1996). It appeared that women who have experienced depression in the past are vulnerable to both depression and anxiety during pregnancy, postpartum, as well as to persistent symptoms that extend well beyond the perinatal period. In fact, the recurrence of these mental illnesses around childbirth could be understandable, as the perinatal period is a stressful period in the woman's life, with many changes over a short period, including the baby birth, and the need to adapt to new parenting responsibilities (Britton, 2008). Thus, women who have the tendency to develop depression and/or anxiety may be particularly vulnerable around that time (Britton, 2008). This is in keeping with the literature which indicated that a history of depression significantly increases the risk of developing antepartum and postpartum depression and anxiety (Beck, 2001; Bernazzani et al., 1997; Britton, 2008; Lancaster et al., 2010; Leigh & Milgrom, 2008; O'Hara & Swain, 1996). History of depression was a major predictor of antepartum and moderate-stable depressive trajectory in our first study, with a higher magnitude of impact on the antepartum trajectory, relative to the reference trajectory "low-stable". Similarly, women in the moderate-stable anxiety trajectory were more likely to have past-depression, compared to the very low-stable anxiety trajectory. Likewise, in our second study, past depression predicted moderate-stable, moderate-increasing, and high-decreasing depressive trajectories relative to the low-stable depressive trajectory, and it was associated with the moderate-stable anxiety trajectory relative to the very low-stable anxiety trajectory.

Stress is another significant psychosocial factor that is also well-documented to increase the risk of developing maternal depression and/or anxiety (Leigh & Milgrom, 2008; Manuel et al., 2012). In this present thesis, our results supported that women with high levels of maternal depressive and/or anxiety symptoms were also coping with high stress levels, as a high stress level was the only factor that consistently predicted trajectories with moderate to high depressive and anxiety symptoms, regardless of variation over time or the length of the follow-up period. A satisfactory relationship with the partner also appears to play a protective role against high levels depressive symptoms during pregnancy and in early postpartum. However, this variable was not significant when the follow-up period was extended beyond the early postpartum period.

A variety of sociodemographic factors have been documented as significant predictors of both perinatal depression and anxiety (J H Goodman et al., 2014; Lancaster et al., 2010; Nakku et al., 2006; Wang et al., 2011). However, in the present thesis, only a few sociodemographic factors were significant in multivariate analyses. Though, the effect of sociodemographic predictors may have been underestimated due to the disproportionally high percentages of women with low-risk sociodemographic profiles in our sample. In the present thesis, non-Caucasian ethnicity was associated with the antepartum depressive trajectory in the first study (pregnancy to early postpartum), and with the moderate-stable or the high-decreasing depressive trajectories in the second study (pregnancy to five years postpartum). While a systematic review found inconsistent findings of the effect of ethnicity/race on the risk of antenatal depression (Lancaster et al., 2010), it has been documented that being an immigrant or indigenous woman is associated with increased risk of maternal depression (Ganann et al., 2012; Roy, 2014). Young mother's age predicted the postpartum depressive trajectory in the first study, an observation that is in line with results of Bayrampour et al. (2016) and Skipstein et al. (2010). On the other hand, financial deprivation was significantly associated with the moderate-stable anxiety trajectories in our both studies.

In the current thesis, the only behavioral factor that showed a significant association with depression trajectory was smoking, as women who smoke during pregnancy were more likely to belong to trajectories with high depressive symptoms. Alcohol or recreational drug use were insignificant in both univariate and multivariate analyses. Perhaps, the low prevalence of alcohol and recreational drug use among women in our sample made it hard to find any statistically significant results with those two variables. Le Strat and colleagues found that using substances

(including alcohol, illicit drugs, and cigarettes) is associated with maternal depression (Le Strat et al., 2011).

7.2. Strengths and limitations

Major strengths of this study include the large sample size, the longitudinal nature of the data, and the repeated assessments of participants. The use of validated screening tools that are widely used in both research and clinical settings to screen for depression and anxiety during pregnancy and postpartum was also an important asset to our study. Another distinguishing feature of this study is that the first and the second halves of pregnancy were included in the follow-up, which was essential to understand the evolution of depressive and anxiety symptoms across the antepartum period; a period with increased risk of both disorders.

As with other research studies, this thesis has some limitations. Our sample tended to be low-risk, which may limit the generalizability of our results to other populations, especially high-risk populations. The issue of attrition, although an inherent characteristic of longitudinal designs, may raise concerns that the conclusions drawn in this study would have been different with 100% participant retention rate. Missing data analysis showed that participants who dropped out of the study could be at higher risk of being depressed or anxious, which may have led to the underrating of the severity of these disorders, and may have caused an underestimation of the strength of association between maternal characteristics and maternal depressive and anxiety trajectories. The small number of women who belonged to trajectories with high depressive trajectories may have also impacted the significance and magnitude of association with maternal risk factors. The fact that depressive and anxiety symptoms were measured using standardized self-reported questionnaires rather than a clinical diagnosis may also have limited our study. We only included baseline predictors, which may have changed over time. However, this approach led to the identification of risk factors that present early in pregnancy, which may allow for early targeted preventative measures towards women at high risk.

7.3. Implications

Despite several limitations, results of the current thesis have important implications for healthcare providers and other professionals interested in promoting the mental health of women during the childbearing period. The evidence of the heterogeneity of maternal depressive and anxiety symptoms may necessitate the multiple assessments for these common disorders during pregnancy and the postpartum period, and beyond that, if deemed necessary. Multiple

assessments may help to recognize women at high risk of major depression or anxiety. Furthermore, recognizing these women may allow for early preventative and treatment interventions, which may alter symptom progress over time.

Since psychosocial factors seem to play an essential role in determining women at increased risk of high and/or persistent depressive and anxiety symptoms, screening women for psychosocial factors may allow clinicians to identify women at increased risk of developing maternal depression and/or anxiety, which could have a huge impact on their mental well-being. Clinicians should inquire about past psychiatric illness, as it appears to be a major predictor of perinatal depression and anxiety (Britton, 2008; Lancaster et al., 2010; O'Hara & Swain, 1996), and about stress levels, particularly during pregnancy and around birth, which can be major transitional periods in the woman's level.

7.4. Directions of future research

This thesis fills an important gap in our knowledge about the heterogeneity of maternal depressive and anxiety symptoms and the existence of distinct groups of women with unique trajectories of their symptoms across the perinatal period and beyond, as well as the risk factors that are uniquely associated with some of these trajectories, but there is more work to be done. In fact, several looming questions emerge from the findings. First, it would be valuable to examine trajectories of maternal depression and anxiety among high-risk populations. Women who are at increased risk of depression and/or anxiety based on their sociodemographic profiles may display unique trajectories of their symptoms across the perinatal period and beyond, and the risk factors associated with these trajectories may be distinct from what we have identified in this thesis.

Examining these trajectories among women from different ethnic groups, as well as among immigrants and refugee women resettled in Canada may also show unique features distinct from our results. Furthermore, given the growing evidence of the impact of maternal depression and anxiety on the offspring, examining the impact of these trajectories on the children's developmental and/or psychological outcomes would also be fundamental to understand the relationship between maternal mood disorders and children's outcomes.

7.5. Conclusion

Our study adds to the ongoing understanding of distinct latent trajectory groups of maternal depressive and anxiety symptoms. We were able to identify subgroups of women who follow similar evolution of their maternal depressive and anxiety symptoms over time. Although

most of the women had no depressive or anxiety symptoms during the perinatal period and beyond, some women experienced depressive and/or anxiety symptoms either during pregnancy, postpartum, or both, and these women's symptoms tend to persist well beyond the early postpartum period. We also identified a range of maternal characteristics present prior to or during pregnancy that are associated with trajectories with high depressive or anxiety symptoms. Psychosocial factors, past depression and high stress levels in particular, emerged as the most prominent risk factors of maternal depression and anxiety trajectories, regardless of the length of the follow-up period. Other significant risk factors were unsatisfactory relationship with the partner, non-Caucasian ethnicity, smoking, and young mother's age. All significant risk factors can be identified during regular follow-up and thus, healthcare providers should be watchful for these risk factors that can put the woman at high risk of having elevated depressive and/or anxiety symptoms during pregnancy, postpartum, or beyond. Early prevention of depressive and anxiety symptoms should specifically target pregnant women with certain characteristics, most notably personal history of depression, high stress level. Women with these characteristics are potential candidates for early interventions that may alter the progress of maternal mental health symptoms. Our findings support the need for multiple assessments starting from early pregnancy to the postpartum, which may help to recognize women at high risk of major depression or anxiety.

References

Agrati, D., Browne, D., Jonas, W., Meaney, M., Atkinson, L., Steiner, M., & Fleming, A. (2015). Maternal anxiety from pregnancy to 2 years postpartum: transactional patterns of maternal early adversity and child temperament. *Archives of Women's Mental Health, 18*(5), 693-705. Doi:http://dx.doi.org/10.1007/s00737-014-0491-y

Agresti, A., & Kateri, M. (2011). Categorical data analysis: Springer Berlin Heidelberg.

Alder, J., Fink, N., Bitzer, J., Hösli, I., & Holzgreve, W. (2007). Depression and anxiety during pregnancy: A risk factor for obstetric, fetal and neonatal outcome? A critical review of the literature. The Journal Of Maternal-Fetal & Neonatal Medicine, 20(3), 189-209. http://dx.doi.org/10.1080/14767050701209560

American Psychiatric Association. (2013). Diagnostic and statistical manual of mental disorders (DSM-5®). Washington, DC.: American Psychiatric Pub.

Anand, A., & Charney, D. S. (2000). Norepinephrine dysfunction in depression. *The Journal of Clinical Psychiatry*.

Andersson, L., Sundström-Poromaa, I., Wulff, M., Åström, M., & Bixo, M. (2006). Depression and anxiety during pregnancy and six months postpartum: a follow-up study. *Acta obstetricia et gynecologica Scandinavica, 85*(8), 937-944.

Ashman, S. B., Dawson, G., & Panagiotides, H. (2008). Trajectories of maternal depression over 7 years: relations with child psychophysiology and behavior and role of contextual risks. *Development & Psychopathology, 20*(1), 55-77. Doi:http://dx.doi.org/10.1017/S0954579408000035

Barnett, B., Schaafsma, M., Guzman, A. M., & Parker, G. (1991). Maternal anxiety: a 5-year review of an intervention study. *Journal of Child Psychology and Psychiatry, 32*(3), 423-438.

Bayrampour, H., Tomfohr, L., & Tough, S. (2016). Trajectories of perinatal depressive and anxiety symptoms in a community cohort. *The Journal of Clinical Psychiatry, 77*(11), e1467.

Beck, C. T. (2001). Predictors of postpartum depression: An update. *Nursing Research, 50*(5), 275-285.

Beck, C. T. (2002). Theoretical perspectives of postpartum depression and their treatment implications. *MCN: The American Journal of Maternal/Child Nursing, 27*(5), 282-287.

Bernard-Bonnin, A., Burrows, K., Ford-Jones, A., Fortin, G., Longstaffe, S., Prince, T., . . . Committee, P. P. (2004). Maternal depression and child development. *Paediatr Child Health, 9*(8), 575-583.

Bernazzani, O., Saucier, J.-F., David, H., & Borgeat, F. (1997). Psychosocial predictors of depressive symptomatology level in postpartum women. *Journal of Affective Disorders, 46*(1), 39-49.

Bloch, M., Schmidt, P. J., Danaceau, M., Murphy, J., Nieman, L., & Rubinow, D. R. (2000). Effects of gonadal steroids in women with a history of postpartum depression. *American Journal of Psychiatry, 157*(6), 924-930.

Bona Bonari, L., Bennett, H., Einarson, A., & Koren, G. (2004). Risks of untreated depression during pregnancy. *Canadian Family Physician*, *50*(1), 37-39.

Bonari, L., Pinto, N., Ahn, E., Einarson, A., Steiner, M., & Koren, G. (2004). Perinatal risks of untreated depression during pregnancy. *Canadian Journal of Psychiatry, 49*(11), 726-735.

Bosquet, M., & Egeland, B. (2001). Associations among maternal depressive symptomatology, state of mind and parent and child behaviors: implications for attachment-based interventions. *Attachment & Human Development, 3*(2), 173-199.

Bowen, A. (2010). *Motherfirst. Maternal Mental Health Strategy: Building Capacity in Saskatchewan*. Retrieved from Saskatoon: http://www.skmaternalmentalhealth.ca/

Bowen, A., Bowen, R., Butt, P., Rahman, K., & Muhajarine, N. (2012). Patterns of depression and treatment in pregnant and postpartum women. *Canadian Journal of Psychiatry, 57*(3).

Bowen, A., Bowen, R., Maslany, G., & Muhajarine, N. (2008). Anxiety in a socially high-risk sample of pregnant women in Canada. *Canadian Journal of Psychiatry, 53*(7), 435-440.

Bowen, A., Stewart, N., Baetz, M., & Muhajarine, N. (2009). Antenatal depression in socially high-risk women in Canada. *Journal of Epidemiology and Community Health, 63*, 414-416.

Bowen, A. N., Bowen, R. C., Balbeuna, L., & Muhajarine, N. (2012). Are pregnant and postpartum women moodier? understanding perinatal mood instability. *Journal of Obstetrics and Gynecology of Canada, 34*(11), 1038-1042.

Britton, J. R. (2008). Maternal anxiety: course and antecedents during the early postpartum period. *Depression and anxiety, 25*(9), 793-800.

Buist, A., Barnett, B. E. W., Milgrom, J., Pope, S., Condon, J. T., Ellwood, D. A., . . . Hayes, B. A. (2002). To screen or not to screen--That is the question in perinatal depression. *Medical Journal of Australia, 177*, s101-s104.

Buist, A., Gotman, N., & Yonkers, K. A. (2011). Generalized anxiety disorder: course and risk factors in pregnancy. *Journal of Affective Disorders, 131*(1), 277-283.

Campbell, S. B., Matestic, P., von Stauffenberg, C., Mohan, R., & Kirchner, T. (2007). Trajectories of maternal depressive symptoms, maternal sensitivity, and children's functioning at school entry. *Developmental Psychology, 43*(5), 1202-1215.

Centers for Disease Control Prevention. (2008). Prevalence of self-reported postpartum depressive symptoms--17 states, 2004-2005. *MMWR. Morbidity and Mortality Weekly Report, 57*(14), 361.

Cents, R. A. M., Diamantopoulou, S., Hudziak, J. J., Jaddoe, V. W. V., Hofman, A., Verhulst, F. C., . . . Tiemeier, H. (2013). Trajectories of maternal depressive symptoms predict child problem behaviour: the Generation R study. *Psychological Medicine, 43*(1), 13-25. Doi:http://dx.doi.org/10.1017/S0033291712000657

Christensen, A. L., Stuart, E. A., Perry, D. F., & Le, H.-N. (2011). Unintended pregnancy and perinatal depression trajectories in low-income, high-risk Hispanic immigrants. *Prevention Science, 12*(3), 289-299. Doi:http://dx.doi.org/10.1007/s11121-011-0213-x

Cox, J. L., & Holden, J. M. (2003). *Perinatal Mental Health: A guide to the Edinburgh Postnatal Depression Scale*. Glasgow, UK: Bell & Bain Ltd.

Cox, J. L., Holden, J. M., & Sagovsky, R. (1987). Detection of postnatal depression. Development of the 10-item Edinburgh Postnatal Depression Scale. *British Journal of Psychiatry, 150*, 782-786.

Crown, W. H., Finkelstein, S., Berndt, E. R., Ling, D., Poret, A. W., Rush, A. J., & Russell, J. M. (2002). The impact of treatment-resistant depression on health care utilization and costs. *Journal of Clinical Psychiatry, 63*(11), 963-971.

Cummings, E., & Davies, P. (1994). Maternal depression and child development. *The Journal of Child Psychology and Psychiatry, 35*(1), 73-122.

Cunningham, F., Leveno, K., Bloom, S., Hauth, J., Rouse, D., & Spong, C. (2009). *Williams Obstetrics* (23 ed.). New York: mcgraw-Hill.

Dayan, J., Creveuil, C., Herlicoviez, M., Herbel, C., Baranger, E., Savoye, C., & Thouin, A. (2002). Role of anxiety and depression in the onset of spontaneous preterm labor. *American Journal of Epidemiology, 155*(4), 293-301.

Dennis, C., & Hodnett, e. (2007). Psychosocial and psychological interventions for treating postpartum depression. *Cochrane Database Systematic Review, 4*, CD006116.

Diego, M. A., Field, T., Hernandez-Reif, M., Cullen, C., Schanberg, S., & Kuhn, C. (2004). Prepartum, postpartum, and chronic depression effects on newborns. *Psychiatry, 67*(1), 63-80.

Dipietro, J. A., Hilton, S. C., Hawkins, M., Costigan, K. A., & Pressman, E. K. (2002). Maternal stress and affect influence fetal neurobehavioral development. *Developmental Psychology, 38*(5), 659.

Doheny, K. (2008). Depression and Divorce: How does depression affect marriage and relationships? Retrieved from http://www.webmd.com/depression/features/divorcing-depression

Don, B. P., Chong, A., Biehle, S. N., Gordon, A., & Mickelson, K. D. (2014). Anxiety across the transition to parenthood: change trajectories among low-risk parents. *Anxiety, Stress, & Coping, 27*(6), 633-649. Doi:http://dx.doi.org/10.1080/10615806.2014.903473

Ersek, J. L., & Brunner Huber, L. R. (2009). Physical activity prior to and during pregnancy and risk of postpartum depressive symptoms. *Journal of Obstetric, Gynecologic, & Neonatal Nursing, 38*(5), 556-566.

Essex, M. J., Klein, M. H., Miech, R., & Smider, N. A. (2001). Timing of initial exposure to maternal major depression and children's mental health symptoms in kindergarten. *The British Journal of Psychiatry, 179*(2), 151-156.

Evans, J., Melotti, R., Heron, J., Ramchandani, P., Wiles, N., Murray, L., & Stein, A. (2012). The timing of maternal depressive symptoms and child cognitive development: A longitudinal study. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 53*(6), 632-640. Doi:10.1111/j.1469-7610.2011.02513.x

Farr, S. L., Dietz, P. M., O'Hara, M. W., Burley, K., & Ko, J. Y. (2014). Postpartum anxiety and comorbid depression in a population-based sample of women. *Journal of Women's Health, 23*(2), 120-128.

Feldman, R., Granat, A., Pariente, C., Kanety, H., Kuint, J., & Gilboa-Schechtman, E. (2009). Maternal depression and anxiety across the postpartum year and infant social engagement, fear regulation, and stress reactivity. *Journal of American Academy of Child & Adolescent Psychiatry, 48*(9), 919-927.

Field, T., Diego, M., Hernandez-Reif, M., Figueiredo, B., Schanberg, S., & Kuhn, C. (2008). Chronic prenatal depression and neonatal outcome. *Informa Healthcare, 118*, 95-103.

Figueiredo, B., & Conde, A. (2011). Anxiety and depression in women and men from early pregnancy to 3-months postpartum. *Archives of Women's Mental Health, 14*(3), 247-255.

Fihrer, I., mcmahon, C. A., & Taylor, A. J. (2009). The impact of postnatal and concurrent maternal depression on child behaviour during the early school years. *Journal of Affective Disorders, 119*(1), 116-123.

Galal, M., Symonds, I., Murray, H., Petraglia, F., & Smith, R. (2012). Postterm pregnancy. *Facts, views & vision in obgyn, 4*(3), 175.

Ganann, R., Sword, W., Black, M., & Carpio, B. (2012). Influence of maternal birthplace on postpartum health and health services use. *Journal of Immigrant and Minority Health, 14*(2), 223-229. Doi:10.1007/s10903-011-9477-2

Giallo, R., Cooklin, A., & Nicholson, J. M. (2014). Risk factors associated with trajectories of mothers' depressive symptoms across the early parenting period: an Australian population-based longitudinal study. *Archives of Women's Mental Health, 17*(2), 115-125. Doi:http://dx.doi.org/10.1007/s00737-014-0411-1

Glover, V., & O'Connor, T. (2006). Maternal anxiety: Its effect on the fetus and the child. *British Journal of Midwifery, 14*(11), 663-667.

Golding, J. M. (1999). Intimate Partner Violence as a Risk Factor for Mental Disorders: A Meta-Analysis. *Journal of Family Violence, 14*(2), 34-34. Doi:10.1023/A:1022079418229

Goodman, J. H. (2004). Paternal postpartum depression, its relationship to maternal postpartum depression, and its implications for family health. *Journal of Advanced Nursing, 45*(1), 26-35.

Goodman, J. H., Chenausky, K. L., & Freeman, M. P. (2014). Anxiety disorders during pregnancy: a systematic review. *The Journal of clinical psychiatry, 75*(10), 1153-1184.

Goodman, J. H., Chenausky, K. L., & Freeman, M. P. (2014). Anxiety disorders during pregnancy: a systematic review. *Journal of Clinical Psychiatry, 75*(10), e1153-1184. Doi:10.4088/JCP.14r09035

Goodman, S. H. (2007). Depression in mothers. *Annual Review of Clinical Psychology, 3*, 107-135.

Goveas, J., Espeland, M., Hogan, P., Tindle, H., Shih, R., Kotchen, J., . . . Resnick, S. (2014). Depressive symptoms and longitudinal changes in cognition: women's health initiative study of cognitive aging. *Journal of Geriatric Psychiatry & Neurology*.

Goyal, D., Gay, C., & Lee, K. A. (2010). How much does low socioeconomic status increase the risk of prenatal and postpartum depressive symptoms in first-time mothers? *Women's Health Issues, 20*(2), 96-104.

Grant, K., mcmahon, C., & Austin, M.-P. (2008). Maternal anxiety during the transition to parenthood: a prospective study. *Journal of Affective Disorders, 108*(1), 101-111.

Grant, K., mcmahon, C., Austin, M. P., Reilly, N., Leader, L., & Ali, S. (2009). Maternal prenatal anxiety, postnatal caregiving and infants' cortisol responses to the still-face procedure. *Developmental Psychobiology, 51*(8), 625-637.

Gross, H. E., Shaw, D. S., Burwell, R. A., & Nagin, D. S. (2009). Transactional processes in child disruptive behavior and maternal depression: A longitudinal study from early childhood to adolescence. *Development and Psychopathology, 21*(01), 139-156.

Gürel, S. A., & Gürel, H. (2000). The evaluation of determinants of early postpartum low mood: the importance of parity and inter-pregnancy interval. *European Journal of Obstetrics & Gynecology and Reproductive Biology, 91*(1), 21-24.

Hansen, D., Lou, H. C., & Olsen, J. (2000). Serious life events and congenital malformations: a national study with complete follow-up. *The Lancet, 356*(9233), 875-880.

Haviland, A. M., Jones, B. L., & Nagin, D. S. (2011). Group-based trajectory modeling extended to account for nonrandom participant attrition. *Sociological Methods & Research*, 0049124111400041.

Hedegaard, M., Henriksen, T. B., Sabroe, S., & Secher, N. J. (1993). Psychological distress in pregnancy and preterm delivery. *BMJ, 307*(6898), 234-239.

Heron, J., Haque, S., Oyebode, F., Craddock, N., & Jones, I. (2009). A longitudinal study of hypomania and depression symptoms in pregnancy and the postpartum period. *Bipolar Disorders, 11*(4), 410-417.

Heron, J., O'Connor, T. G., Evans, J., Golding, J., Glover, V., & O'Connor, T. G. (2004). The course of anxiety and depression through pregnancy and the postpartum in a community sample. *Journal of Affective Disorders, 80*(1), 65-73.

Hranov, L. G. (2007). Comorbid anxiety and depression: illumination of a controversy. *International Journal of Psychiatry in Clinical Practice, 11*(3), 171-189.

Hunter, S. K., Mendoza, J. H., D'Anna, K., Zerbe, G. O., mccarthy, L., Hoffman, C., . . . Ross, R. G. (2012). Antidepressants may mitigate the effects of prenatal maternal anxiety on infant auditory sensory gating. *American Journal of Psychiatry*.

Jonas, W., Nissen, E., Ransjö-Arvidson, A., Matthiesen, A., & Uvnäs-Moberg, K. (2008). Influence of oxytocin or epidural analgesia on personality profile in breastfeeding women: a comparative study. *Archives of Women's Mental Health, 11*(5-6), 335-345.

Jones, B. L., & Nagin, D. S. (2007). Advances in group-based trajectory modeling and an SAS procedure for estimating them. *Sociological Methods & Research, 35*(4), 542-571.

Jones, B. L., Nagin, D. S., & Roeder, K. (2001). A SAS procedure based on mixture models for estimating developmental trajectories. *Sociological Methods & Research, 29*(3), 374-393.

Kahn, R. S., Brandt, D., & Whitaker, R. C. (2004). Combined effect of mothers' and fathers' mental health symptoms on children's behavioral and emotional well-being. *Archives of Pediatric & Adolescent Medicine, 158*, 721-729.

Katon, W. J. (2003). Clinical and health services relationships between major depression, depressive symptoms, and general medical illness. *Biological Psychiatry, 54*(3), 216-226.

Kessler, R. C., mcgonagle, K. A., Swartz, M., Blazer, D. G., & Nelson, C. B. (1993). Sex and depression in the National Comorbidity Survey I: Lifetime prevalence, chronicity and recurrence. *Journal of Affective Disorders, 29*(2-3), 85-96.

Kessler, R. C., mcgonagle, K. A., Zhao, S., Nelson, C. B., Hughes, M., Eshleman, S., . . . Kendler, K. S. (1994). Lifetime and 12-month prevalence of DSM III-R psychiatric disorders in the United States. Results from the National Comorbidity Survey. *Archives of General Psychiatry, 51*(1), 8-19.

Kuo, S.-Y., Chen, S.-R., & Tzeng, Y.-L. (2014). Depression and anxiety trajectories among women who undergo an elective cesarean section. *Plos ONE [Electronic Resource], 9*(1), e86653. Doi:http://dx.doi.org/10.1371/journal.pone.0086653

Kuo, S.-Y., Yang, Y.-L., Kuo, P.-C., Tseng, C.-M., & Tzeng, Y.-L. (2012). Trajectories of depressive symptoms and fatigue among postpartum women. *JOGNN - Journal of Obstetric, Gynecologic, & Neonatal Nursing, 41*(2), 216-226. Doi:http://dx.doi.org/10.1111/j.1552-6909.2011.01331.x

Kurki, T., Hiilesmaa, V., Raitasalo, R., Mattila, H., & Ylikorkala, O. (2000). Depression and anxiety in early pregnancy and risk for preeclampsia. *Obstetrics & Gynecology, 95*(4), 487-490.

Lancaster, C. A., Gold, K. J., Flynn, H. A., Yoo, H., Marcus, S. M., & Davis, M. M. (2010). Risk factors depressive symptoms during pregnancy: A systematic review. *American Journal of Obstetrics & Gynecology, 202*(1), 5-14.

Lancaster, C. A., Gold, K. J., Flynn, H. A., Yoo, H., Marcus, S. M., & Davis, M. M. (2010). Risk factors for depressive symptoms during pregnancy: a systematic review. *American Journal of Obstetrics and Gynecology, 202*(1), 5-14. Doi:10.1016/j.ajog.2009.09.007

Lanes, A., Kuk, J. L., & Tamim, H. (2011). Prevalence and characteristics of postpartum depression symptomatology among Canadian women: a cross-sectional study. *BMC Public Health, 11*(1), 302.

Le Strat, Y., Dubertret, C., & Le Foll, B. (2011). Prevalence and correlates of major depressive episode in pregnant and postpartum women in the United States. *Journal of Affective Disorders, 135*(1), 128-138.

Leach, L. S., Poyser, C., & Fairweather-Schmidt, K. (2015). Maternal perinatal anxiety: A review of prevalence and correlates. *Clinical Psychologist*.

Lee, C.-T., Stroo, M., Fuemmeler, B., Malhotra, R., & Ostbye, T. (2014). Trajectories of depressive symptoms over 2 years postpartum among overweight or obese women. *Womens Health Issues, 24*(5), 559-566. Doi:http://dx.doi.org/10.1016/j.whi.2014.05.008

Leigh, B., & Milgrom, J. (2008). Risk factors for antenatal depression, postnatal depression and parenting stress. *BMC psychiatry, 8*(24).

Letourneau, N. L., Dennis, C.-L., Benzies, K., Duffett-Leger, L., Stewart, M., Tryphonopoulos, P. D., . . . Watson, W. (2012). Postpartum depression is a family affair: addressing the

impact on mothers, fathers, and children. *Issues in Mental Health Nursing, 33*(7), 445-457.

Lilliecreutz, C., Sydsjö, G., & Josefsson, A. (2011). Obstetric and perinatal outcomes among women with blood-and injection phobia during pregnancy. *Journal of Affective Disorders, 129*(1), 289-295.

Luoma, I., Korhonen, M., Salmelin, R. K., Helminen, M., & Tamminen, T. (2015). Long-term trajectories of maternal depressive symptoms and their antenatal predictors. *Journal of Affective Disorders, 170*, 30-38. Doi:http://dx.doi.org/10.1016/j.jad.2014.08.017

Macbeth, A. H., & Luine, V. N. (2010). Changes in anxiety and cognition due to reproductive experience: a review of data from rodent and human mothers. *Neuroscience & Biobehavioral Reviews, 34*(3), 452-467.

Madigan, S., Wade, M., Plamondon, A., Vaillancourt, K., Jenkins, J. M., Shouldice, M., & Benoit, D. (2014). Course of depression and anxiety symptoms during the transition to parenthood for female adolescents with histories of victimization. *Child abuse & neglect, 38*(7), 1160-1170.

Manuel, J. I., Martinson, M. L., Bledsoe-Mansori, S. E., & Bellamy, J. L. (2012). The influence of stress and social support on depressive symptoms in mothers with young children. *Social Science & Medicine, 75*(11), 2013-2020.

Matijasevich, A., Murray, J., Cooper, P. J., Anselmi, L., Barros, A. J. D., Barros, F. C., & Santos, I. S. (2015). Trajectories of maternal depression and offspring psychopathology at 6 years: 2004 Pelotas cohort study. *Journal of Affective Disorders, 174*, 424-431. Doi:http://dx.doi.org/10.1016/j.jad.2014.12.012

Matthey, S., Fisher, J., & Rowe, H. (2013). Using the Edinburgh postnatal depression scale to screen for anxiety disorders: Conceptual and methodological considerations. *Journal of Affective Disorders, 146*(2), 224-230. Doi:10.1016/j.jad.2012.09.009

Matthey, S., Valenti, B., Souter, K., & Ross-Hamid, C. (2013). Comparison of four self-report measures and a generic mood question to screen for anxiety during pregnancy in English-speaking women. *Journal of Affective Disorders, 148*(2), 347-351.

Mayberry, L. J., Horowitz, J. A., & Declercq, E. (2007). Depression symptom prevalence and demographic risk factors among US women during the first 2 years postpartum. *Journal of Obstetric, Gynecologic, & Neonatal Nursing, 36*(6), 542-549.

Mayou, R., & Smith, K. (1997). Post traumatic symptoms following medical illness and treatment. *Journal of Psychosomatic Research, 43*(2), 121-123.

Mccue Horwitz, S., Briggs-Gowan, M. J., Storfer-Isser, A., & Carter, A. S. (2007). Prevalence, correlates, and persistence of maternal depression. *Journal of Women's Health, 16*(5), 678-691.

Mccue Horwitz, S., Briggs-Gowan, M. J., Storfer-Isser, A., & Carter, A. S. (2009). Persistence of maternal depressive symptoms throughout the early years of childhood. *Journal of Women's Health, 18*(5), 637-645.

Mclennan, J. D., Kotelchuck, M., & Cho, H. (2001). Prevalence, persistence, and correlates of depressive symptoms in a national sample of mothers of toddlers. *Journal of the American Academy of Child & Adolescent Psychiatry, 40*(11), 1316-1323.

Merikangas, K., Lieb, R., Wittchen, H. U., & Avenevoli, S. (2003). Family and high-risk studies of social anxiety disorder. *Acta Psychiatrica Scandinavica, 108*(s417), 28-37.

Misri, S., & Kendrick, K. (2008). Perinatal depression, fetal bonding, and mother-child attachment: A review of the literature. *Current Pediatric Reviews, 4*(2), 66-70.

Mora, P. A., Bennett, I. M., Elo, I. T., Mathew, L., Coyne, J. C., & Culhane, J. F. (2009). Distinct trajectories of perinatal depressive symptomatology: evidence from growth mixture modeling. *American Journal of Epidemiology, 169*(1), 24-32. Doi:http://dx.doi.org/10.1093/aje/kwn283

Murray, L., & Cooper, P. J. (2003). Intergenerational transmission of affective and cognitive processes associated with depression: infancy and the pre-school years. In I. Goodyer (Ed.), (pp. 17-42). Oxford: Oxford University Press.

Murray, L., Hipwell, A., Hooper, R., Stein, A., & Cooper, P. (1996). The cognitive development of 5-year-old children of postnatally depressed mothers. *Journal of Child Psychology and Psychiatry, 37*(8), 927-935.

Nagin, D. S. (1999). Analyzing developmental trajectories: a semiparametric, group-based approach. *Psychological methods, 4*(2), 139.

Nagin, D. S. (2005). *Group-based modeling of development*. Cambridge, Mass: Harvard University Press

Nagin, D. S., & Odgers, C. L. (2010). Group-based trajectory modeling in clinical research. *Annual Review of Clinical Psychology, 6*, 109-138.

Nakku, J., Nakasi, G., & Mirembe, F. (2006). Postpartum major depression at six weeks in primary health care: prevalence and associated factors. *African Health Sciences, 6*(4).

Nandi, A., Beard, J. R., & Galea, S. (2009). Epidemiologic heterogeneity of common mood and anxiety disorders over the lifecourse in the general population: a systematic review. *BMC Psychiatry, 9*(1), 31.

O'Brien, L., Laporte, A., & Koren, G. (2009). Estimating economic costs of antidepressant discontinuation during pregnancy. *The Canadian Journal of Psychiatry, 54*(6), 399-408.

O'Conner, T. G., Heron, J., Glover, V., & Team, A. S. (2002). Antenatal anxiety predicts child behavioral/emotional problems independently of postnatal depression. *Journal of the American Academy of Child & Adolescent Psychiatry, 41*(12), 1470-1477.

O'Hara, M. W., & Swain, A. M. (1996). Rates and risk of postpartum depression - a meta-analysis. *International Review of Psychiatry, 8*, 37-54. Doi:10.3109/09540269609037816

O'Donnell, K. J., Glover, V., Jenkins, J., Browne, D., Ben-Shlomo, Y., Golding, J., & O'Connor, T. G. (2013). Prenatal maternal mood is associated with altered diurnal cortisol in adolescence. *Psychoneuroendocrinology, 38*(9), 1630-1638.

Onunaku, N. (2005). *Improving Maternal and Infant Mental Health: Focus on Maternal Depression.* Los Angeles, CA: National Center for Infant and Early Childhood Health Policy at UCLA.

Anand, A., & Charney, D. S. (2000). Norepinephrine dysfunction in depression. *The Journal of clinical psychiatry*.

Beck, C. T. (2002). Theoretical perspectives of postpartum depression and their treatment implications. *MCN: The American Journal of Maternal/Child Nursing, 27*(5), 282-287.

Bloch, M., Schmidt, P. J., Danaceau, M., Murphy, J., Nieman, L., & Rubinow, D. R. (2000). Effects of gonadal steroids in women with a history of postpartum depression. *American Journal of Psychiatry, 157*(6), 924-930.

Oshima, A., Miyano, H., Yamashita, S., Owashi, T., Suzuki, S., Sakano, Y., & Higuchi, T. (2001). Psychological, autonomic and neuroendocrine responses to acute stressors in the combined dexamethasone/CRH test: a study in healthy subjects. *Journal of Psychiatric Research, 35*(2), 95-104.

Porter, C. L., & Hsu, H.-C. (2003). First-time mothers' perceptions of efficacy during the transition to motherhood: Links to infant temperament. *Journal of Family Psychology, 17*(1), 54.

Preti, A., Cardascia, L., Zen, T., Pellizzari, P., Marchetti, M., Favaretto, G., & Miotto, P. (2000). Obstetric complications in patients with depression—a population-based case–control study. *Journal of Affective Disorders, 61*(1), 101-106.

Rahman, K., Bowen, A., & Muhajarine, N. (2014). Examining the factors that moderate and mediate the effects on depression during pregnancy and postpartum. *Journal of Pregnancy & Child Health, 1*(2).

Rahman, K., Bowen, A., & Muhajarine, N. (2017). Application of pattern mixture models in examining missing data in antenatal and 5 year postnatal follow-up study. *Unpublished manuscript*.

Raudenbush, S. W. (2001). *Toward a coherent framework for comparing trajectories of individual change* L. Collins & A. Sayer (Eds.).

Reay, R., Matthey, S., Ellwood, D., & Scott, M. (2011). Long-term outcomes of participants in a perinatal depression early detection program. *Journal of Affective Disorders, 129*(1), 94-103.

Rivkin, M. J., Davis, P. E., Lemaster, J. L., Cabral, H. J., Warfield, S. K., Mulkern, R. V., . . . Frank, D. A. (2008). Volumetric MRI study of brain in children with intrauterine exposure to cocaine, alcohol, tobacco, and marijuana. *Pediatrics, 121*(4), 741-750.

Robertson, E., Grace, S., Wallington, T., & Stewart, D. E. (2004). Antenatal risk factors for postpartum depression: a synthesis of recent literature. *General Hospital Psychiatry, 26*(4), 289-295.

Roos, A., Faure, S., Lochner, C., Vythilingum, B., & Stein, D. (2013). Predictors of distress and anxiety during pregnancy. *African Journal of Psychiatry, 16*(2), 118-122.

Ross, L. E., Evans, S. G., Sellers, E., & Romach, M. (2003). Measurement issues in postpartum depression part 1: anxiety as a feature of postpartum depression. *Archives of Women's Mental Health, 6*(1), 51-57.

Ross, L. E., & mcclean, L. M. (2006). Anxiety disorders during pregnancy and the postpartum period: A systematic review. *Journal of Clinical Psychiatry, 67*(8), 1285-1298.

Rouse, M., & Goodman, S. (2010). Perinatal Depression and Children: A Developmental Perspective. *Encyclopedia on Early Childhood Development*, 1-7.

Roy, A. (2014). Intergenerational trauma and Aboriginal women: Implications for mental health during pregnancy. *First Peoples Child & Family Review, 9*(1), 7-21.

Rubertsson, C., Waldenström, U., & Wickberg, B. (2003). Depressive mood in early pregnancy: prevalence and women at risk in a national Swedish sample. *Journal of Reproductive and Infant Psychology, 21*(2), 113-123.

Rubertsson, C., waldenström, U., Wickberg, B., Rådestad, I., & Hildingsson, I. (2005). Depressive mood in early pregnancy and postpartum: prevalence and women at risk in a national Swedish sample. *Journal of Reproductive and Infant Psychology, 23*(2), 155-166.

Rubertsson, C., Wickberg, B., Gustavsson, P., & Radestad, I. (2005). Depressive symtoms in early pregnancy, two months and one year postpartum-prevalence and psychosocial risk factors in a national Swedish sample. *Archives of Women's Mental Health, 8*, 97-104.

Santoro, K., & Peabody, H. (2010). Identifying and Treating Maternal Depression : Strategies & Considerations for Health Plans. *Washington, DC: National Institute of Health Care Management*, 1-28.

Schneider, M. L., & Moore, C. F. (2000). *Effect of prenatal stress on development: A nonhuman primate model.* Paper presented at the Minnesota Symposium on Child Psychology.

Seto, M., Cornelius, M. D., Goldschmidt, L., Morimoto, K., & Day, N. L. (2005). Long-term effects of chronic depressive symptoms among low-income childrearing mothers. *Maternal and Child Health Journal, 9*(3), 263-271.

Sichel, D., & Driscoll, J. W. (1999). Women's moods: What every woman must know about hormones, the brain, and emotional health. New York: William Morrow and Company: Inc.

Skipstein, A., Janson, H., Kjeldsen, A., Nilsen, W., & Mathiesen, K. S. (2012). Trajectories of maternal symptoms of depression and anxiety over 13 years: the influence of stress, social support, and maternal temperament. *BMC Public Health, 12*, 1120. Doi:http://dx.doi.org/10.1186/1471-2458-12-1120

Skipstein, A., Janson, H., Stoolmiller, M., & Mathiesen, K. S. (2010). Trajectories of maternal symptoms of anxiety and depression. A 13-year longitudinal study of a population-based sample. *BMC Public Health, 10*, 589. Doi:http://dx.doi.org/10.1186/1471-2458-10-589

So, Y., & Kuhfeld, W. F. (1995). *Multinomial logit models.* Paper presented at the SUGI 20 Conference Proceedings.

Spinelli, M. (2004). Maternal infanticide associated with mental illness: Prevention and the promise of saved lives. *American Journal of Psychiatry, 161*(9), 1548-1557.

Stewart, D. E., Robertson, E., Dennis, C.-L., Grace, S. L., & Wallington, T. (2003). Postpartum depression: Literature review of risk factors and interventions. *Toronto: University Health Network Women's Health Program for Toronto Public Health*.

Strøm, M., Mortensen, E. L., Halldorson, T. I., Osterdal, M. L., & Olsen, S. F. (2009). Leisure-time physical activity in pregnancy and risk of postpartum depression: a prospective study in a large national birth cohort. *The Journal of Clinical Psychiatry, 70*(12), 1707-1714.

Suri, R., Altschuler, L, Hellemann, G, Burt, V, K, Aquino, A, & Mintz, J, . (2007). Effects of antenatal depression and antidepressant treatment on gestational age at birth and risk of preterm birth. *American Journal of Psychiatry, 164*(8), 1206-1213.

Suri, R., Lin, A. S., Cohen, L. S., & Altshuler, L. L. (2014). Acute and long-term behavioral outcome of infants and children exposed in utero to either maternal depression or antidepressants: A review of the literature. *Journal of Clinical Psychiatry, 75*(10), e1142-e1152. Doi:10.4088/JCP.13r08926

Surkan, P. J., Ettinger, A. K., Hock, R. S., Ahmed, S., Strobino, D. M., & Minkovitz, C. S. (2014). Early maternal depressive symptoms and child growth trajectories: a longitudinal analysis of a nationally representative US birth cohort. *BMC Pediatrics, 14*, 185. Doi:http://dx.doi.org/10.1186/1471-2431-14-185

Sutter-Dallay, A. L., Cosnefroy, O., Glatigny-Dallay, E., Verdoux, H., & Rascle, N. (2012). Evolution of perinatal depressive symptoms from pregnancy to two years postpartum in a low-risk sample: the MATQUID cohort. *Journal of Affective Disorders, 139*(1), 23-29. Doi:http://dx.doi.org/10.1016/j.jad.2011.08.018

Sutter-Dallay, A. L., Giaconne-Marcesche, B., Glatigny-Dallay, E., & Vedoux, H. (2004). Women with anxiety disorders during pregnancy are at increased risk of intense postnatal depressive symptoms: a prospective survey of the MATQUID cohort. *European Psychiatry, 19*(8), 459-463.

Tearne, J. E., Allen, K. L., Herbison, C. E., Lawrence, D., Whitehouse, A. J. O., Sawyer, M. G., & Robinson, M. (2015). The association between prenatal environment and children's

mental health trajectories from 2 to 14 years. *European Child & Adolescent Psychiatry, 24*(9), 1015-1024. Doi:http://dx.doi.org/10.1007/s00787-014-0651-7

Teissedre, F., & Chabol, H. (2003). Postnatal depression: a study of the predictive effects of postnatal anxiety. *Irish Journal of Psychological Medicine, 20*(04), 111-114.

The American College of Obstetricians & Gynecologists. (2015). Screening for perinatal depression: Committee Opinion No. 630. *Obstetrics and gynecology, 125*(630), 1268-1271.

Thompson, B. L., Levitt, P., & Stanwood, G. D. (2009). Prenatal exposure to drugs: effects on brain development and implications for policy and education. *Nature Reviews Neuroscience, 10*(4), 303-312.

Tiedje, L. B. (2009). The prevalence of postpartum depression: the relative significance of three social status indices. *MCN: The American Journal of Maternal/Child Nursing, 34*(3), 196.

Turney, K. (2012). Pathways of disadvantage: Explaining the relationship between maternal depression and children's problem behaviors. *Social Science Research, 41*(6), 1546-1564.

Van der Waerden, J., Galera, C., Saurel-Cubizolles, M. J., Sutter-Dallay, A. L., Melchior, M., & Group, E. M.-C. C. S. (2015). Predictors of persistent maternal depression trajectories in early childhood: results from the EDEN mother-child cohort study in France. *Psychological Medicine, 45*(9), 1999-2012. Doi:http://dx.doi.org/10.1017/S003329171500015X

Van Veen, J. F., Jonker, B. W., Van Vliet, I. M., & Zitman, F. G. (2009). The effects of female reproductive hormones in generalized social anxiety disorder. *The International Journal of Psychiatry in Medicine, 39*(3), 283-295.

Vänskä, M., Punamäki, R.-L., Tolvanen, A., Lindblom, J., Flykt, M., Unkila-Kallio, L., . . . Tulppala, M. (2011). Maternal pre-and postnatal mental health trajectories and child mental health and development: Prospective study in a normative and formerly infertile sample. *International Journal of Behavioral Development, 35*(6), 517-531.

Vesga-Lopez, O., Blanco, C., Keyes, K., Olfson, M., Grant, B. F., & Hasin, D. S. (2008). Psychiatric disorders in pregnant and postpartum women in the United States. *Archives of General Psychiatry, 65*(7), 805-815.

Wang, J. L. (2004). The difference between single and married mothers in the 12-month prevalence of major depressive syndrome, associated factors and mental health service utilization. *Social Psychiatry and Psychiatric Epidemiology, 39*(1), 26-32.

Wang, L., Wu, T., Anderson, J. L., & Florence, J. E. (2011). Prevalence and risk factors of maternal depression during the first three years of child rearing. *Journal of Women's Health, 20*(5), 711-718.

Wasserman, L. (2000). Bayesian model selection and model averaging. *Journal of mathematical psychology, 44*(1), 92-107.

Wenzel, A., Haugen, E. N., Jackson, L. C., & Brendle, J. R. (2005). Anxiety symptoms and disorders at eight weeks postpartum. *Journal of Anxiety Disorders, 19*(3), 295-311.

Westall, C., & Liamputtong, P. (2011). *Motherhood and postnatal depression: Narratives of women and their partners*: Springer Science & Business Media.

WHO. (2013). Investing in mental health: evidence for action. Retrieved from http://apps.who.int/iris/bitstream/10665/87232/1/9789241564618_eng.pdf

WHO. (2016a). Maternal mental health. Retrieved from http://www.who.int/mental_health/maternal-child/maternal_mental_health/en/

WHO. (2016b). Preterm birth. . Retrieved from http://www.who.int/mediacentre/factsheets/fs363/en/

WHO. (2017a). Depression and other common mental disorders: global health estimates. Retrieved from http://apps.who.int/iris/handle/10665/254610

WHO. (2017b). Maternal and perinatal health. Retrieved from http://www.who.int/maternal_child_adolescent/topics/maternal/maternal_perinatal/en/

Wisner, K. L., Parry, B. L., & Piontek, C. M. (2002). Postpartum depression. *New England Journal of Medicine, 347*(3), 194-199.

Zimmer, Z., Martin, L. G., Nagin, D. S., & Jones, B. L. (2012). Modeling disability trajectories and mortality of the oldest-old in China. *Demography, 49*(1), 291-314.

Appendices

Appendix A

Previous research studies on trajectories of maternal depression and/or anxiety

uthor	Sample	Assessment	Statistical methodology	Trajectories	%	Maternal predictors
′an der /aerden et ., 2015)	1807 women in France	Depressive symptoms were assessed using Center for Epidemiological Studies-Depression (CES-D) questionnaire At pregnancy, 4, 8, 12, 36, 60 months after giving birth	Semi-parametric group-based modeling strategy	No symptoms	60%	Reference.
				Persistent intermediate-level depressive symptoms	25%	More likely to had experienced major life event during pregnancy, work stress, pre-pregnancy mental health treatment, and high levels of antenatal anxiety symptoms than the reference group.
				Persistent high depressive symptoms	5%	More likely to be originally non-French, to have a history of childhood adversity, a high work stress, a history of mental illness and high levels of antenatal anxiety symptoms than the reference group.
				High Symptoms only in pregnancy	5%	More likely to be originally non-French, to have a history of childhood adversity, a history of mental illness, pre-pregnancy substance use, high levels of antenatal anxiety symptoms, and to lack social support than the reference group.
				High symptoms only in the child's preschool period	5%	More likely to have a partner educational level <12 years, a pre-pregnancy mental health treatment, and high levels of antenatal anxiety symptoms than the reference group.
Sutter-allay et al., 012)	579 low-risk women in Finland	Depressive symptoms were assessed using CES-D at 8 months of pregnancy, and at 3 days, six	Semi-parametric group-based modeling strategy	Never	72%	Reference
				Postpartum	4%	-

uthor	Sample	Assessment	Statistical methodology	Trajectories	%	Maternal predictors
		weeks, 3, 6, 12, 18 and 24 months after giving birth.		Antepartum	21%	Older, had lower income and higher anxiety trait scale than the reference group.
				Chronic	3%	Higher anxiety trait scale than the reference group.
Cents et al., 013)	4167 women in Netherlands	Depressive symptoms were assessed using the brief symptom inventory at pregnancy (18–25 weeks), 2, 6, and 36 months after birth	Semi-parametric group-based modeling strategy	No symptoms	34%	Reference.
				Low depressive symptoms	54%	Parity ≥1, more likely to have non-Dutch ethnicity, a history of depressive mood, and more family stress than the reference group.
				Moderate depressive symptoms	11%	Lower income, parity≥1, more likely to have non-Dutch ethnicity, a history of depressive mood, and more family stress than the reference group.
				High depressive symptoms	2%	Lower maternal age, lower educational level, lower income, more likely to have non-Dutch ethnicity, a history of depressive mood, and more family stress than the reference group.
Campbell et ., 2007)	1,261 women in the USA	Depressive symptoms were assessed for using CES-D at 1, 6, 15, 24, 36, and 54 months after birth and when the child was 7-years old	Semi-parametric group-based modeling strategy	High– chronic	3%	Lower education, lower income, and were more likely to be in unstable marriages and less likely to be Caucasian than the low-stable group
				Moderate–increasing	6%	Younger, and had lower education and income, than women in the low-stable group
				High–decreasing	6%	Younger, had lower education and income, less likely to be Caucasian, and less likely to be in stable marriages than women in the low-stable group
				Intermittent	4%	

uthor	Sample	Assessment	Statistical methodology	Trajectories	%	Maternal predictors
						Younger, and had lower education and income, than women in the low-stable group
				Moderate–stable	36%	Younger, and had lower education and income, than women in the low-stable group. Had better income and educatior compared to women in high chronic and high-decreasing trajectory classes
				Low–stable	46%	Older, and had higher education and income, than women in the other 5 groups. Were more likely to be in a stable marriage and Caucasian than women in the increasing, decreasing, and chronic groups
/änskä et ., 2011)	Women from Finland who were previously infertile. Sample size at t1: n=788, at t2: n= 657, and at t3: n=545	Depressive symptoms were assessed using the short form of Beck Depression Inventory (BDI-13). Psychological distress was assessed using General Health Questionnaire (GHQ-36). The assessment was done during the second trimester of pregnancy, at 2 months, and 12 months postpartum.	Mixture modeling	Low level of mental health symptoms	75%	No significant difference in mother's age education, marital status, the number of previous marriages or cohabiting partnerships, baby's birth weight or in the gender of the child, compared to other groups.
				Mental health symptoms only during pregnancy	6%	Were more likely to be multiparous. No significant difference in mother's age education, marital status, the number of previous marriages or cohabiting partnerships, baby's birth weight, or in the gender of the child, compared to other groups.
				Mental health symptoms during early postpartum period	9%	Were more likely to be primiparous. No significant difference in mother's age education, marital status, the number of previous marriages or cohabiting partnerships, baby's birth weight, or in the gender of

uthor	Sample	Assessment	Statistical methodology	Trajectories	%	Maternal predictors
						the child, compared to other groups.
				Mental health symptoms during late postpartum period	6%	No significant difference in mother's age education, marital status, the number of previous marriages or cohabiting partnerships, baby's birth weight or in the gender of the child, compared to other groups.
				Heterogeneous high level mental health symptoms	4%	No significant difference in mother's age education, marital status, the number of previous marriages or cohabiting partnerships, baby's birth weight or in the gender of the child, compared to other groups.
Gross et al., 009)	289 mothers of male toddlers from low-income families in the USA	Depressive symptoms were assessed for using Beck Depression Inventory (BDI) at 1.5, 2, 3.5, 5, 5.5, 6, 8, 10, 11, and 12 years after birth	Semi-parametric group-based modeling strategy	Low	25%	-
				Moderate low	46%	-
				Moderate high	22%	-
				High chronic	7%	Lower family income than the low symptoms' category.
Luoma et ., 2015)	329 women from Finland	Depressive symptoms were assessed using EPDS during pregnancy and at 2 months, 6 months, 4-5 years, 8-9 years, and 16-17 years after giving birth	Semi-parametric group-based modeling strategy	Very low	18%	Reference group.
				Low stable	53%	Reference group (both groups were combined).
				High stable	27%	Higher antenatal EPDS scores, higher antenatal EPDS-anxiety subscale, lower satisfaction of life, higher NPI average baby form, lower partner educational level, and were more likely to feel lonely, to have ever smoked to have difficulties during pregnancy, and to have not very good relationship with partner

uthor	Sample	Assessment	Statistical methodology	Trajectories	%	Maternal predictors
						than women in the very low and low stable groups combined
				Intermittent	3%	Higher antenatal EPDS scores, higher mother's age, and more likely to have poor relationship with mother, urgent need to conceive, past or current mental illness, not very good perceived health, lost mother and lost fathe than women in the very low and low stable groups combined
Skipstein et ., 2010)	951 women in Norway	Depressive and anxiety symptoms were assessed using Hopkins symptom checklist (HSCL-25) at 18 months, 2.5 years, 4.5 years, 8.5 years, 12.5 years, and 14.5 years after birth	Latent profile analysis	No symptoms	5%	-
				Low	19%	Significantly older than women in the high chronic group, and were most often living with a partner.
				Moderate-low	30%	More likely to have a boy than other groups.
				Moderate	32%	-
				Chronic high	10%	Younger than women in the low group. Have significantly lower education than women in other groups, were less likely to have paid work than the rest, and were least often living with a partner.
				Low-rising	4%	-
Skipstein et ., 2012)	951 women in Norway	Depressive and anxiety symptoms were assessed using Hopkins symptom checklist (HSCL-25) at 18 months, 2.5 years, 4.5 years, 8.5 years, 12.5	Latent profile analysis	Low	54%	Reference.
				Moderate	32%	Had higher scores on temperamental Fearfulness and distress, Higher levels of both child related and living related stressors when the index child was 18 months old, compared to the reference group. When compared to the high chronic group, women in this

uthor	Sample	Assessment	Statistical methodology	Trajectories	%	Maternal predictors
		years, and 14.5 years after birth				group have lower levels of temperamental distress, temperamental anger, and higher levels of support from family and friends than the high chronic group.
				Chronic high	10%	Had higher child related stressors, higher levels of stressors related to the living conditions, lower levels of support from both partner, and friends and family, higher scores of the three sub-scales on temperamental emotionality (distress, fearfulness, and anger) Fewer years of education, and were less likely to have paid work compared to the reference group.
				Low-rising	4%	Had higher levels of temperamental distress and lower levels of support from friends and family than women in the reference group. Compared to the high chronic group, women in this group had more support from partner, higher levels of education, lower levels of temperamental anger And lower levels of child related stressors.
Ashman, awson, & anagiotides, 008)	150 women in the USA	Depressive symptoms were assessed using the structured clinical interview For DSM-III-R, the CES-D , and a modified interview version of the	Latent growth mixture modeling	Decreasing depression Chronic depression Stable mild Depression	30% 8% 62%	There was no significant difference among these classes in terms of sociodemographic characteristics (ethnicity, education, occupation, work history, socioeconomic status, and the number of children).

uthor	Sample	Assessment	Statistical methodology	Trajectories	%	Maternal predictors
		longitudinal interval follow-up evaluation at 14 months, 24 months, 3.5 years 4.5 years, and 6.5 years of giving birth.				
Kuo et al., 014)	139 women in Taiwan who had elective CS	Depressive symptoms were assessed using EPDS and anxiety symptoms were assessed using state anxiety inventory during the third trimester and 1 day, 1 week, and 6 months of giving birth	Semi-parametric group-based modeling strategy	Depression trajectories: Low Mild High Anxiety trajectories: Low Mild High Very high	 31% 42% 27% 19% 45% 29% 7%	 Reference. Reference. Have higher BMI before pregnancy and were more likely to have sleep difficulties In the third trimester than wome in reference groups. Reference. Reference. Have higher BMI before pregnancy and were more likely to have sleep difficulties in the third trimester than women in reference groups. Have higher BMI before pregnancy and were more likely to have sleep difficulties in the third trimester than women in reference groups.
Giallo et al., 014)	4879 women in Australia	Depressive symptoms were assessed using the Kessler-6 (K6) during the first year of giving birth (3-12 months, 2-3	Latent growth modeling	Minimal symptoms Persistent high symptoms	84% 16%	Reference. Associated with a young age of mother, low level of education, a history of depression, the antenatal use of antidepressants, child developmental problems,

uthor	Sample	Assessment	Statistical methodology	Trajectories	%	Maternal predictors
		years, 4-5 years, and 6-7 years after giving birth				low parent's self-efficacy, stressful life event, and relationship problems.
Matijasevich al., 2015)	4231 women in Brazil	Depressive symptoms were assessed using EPDS at 3, 12, 24 and 48 months and 6 years after delivery	Semi-parametric group-based modeling strategy	Low	35%	More likely to be white, to have early prenatal care, and to have planned pregnancy, and had higher income and education tha women in other groups. They were older than mothers in the moderate-low, increasing and decreasing groups.
				Moderate-low	41%	Younger than women in low and chronic high groups
				Increasing	9%	Had a higher frequency of preterm birth than women in other groups. Had higher proportions of single mothers than women in low, moderate-low, and chronic high groups.
				Decreasing	10%	Had higher proportions of single mothers than women in low, moderate-low, and chronic high groups
				Chronic high	5%	More likely to be multiparous, to have antenatal depressive symptoms, and more likely to smoke and consume alcohol during pregnancy than women in other groups. They were older than mothers in the moderate-low, increasing and decreasing groups.
Lee, Stroo, uemmeler, Malhotra, & stbye, 014)	844 overweight and obese women in the USA	Depressive symptoms were assessed using EDPS at 0–5 months, 6–11 months, 12–17 months, 18–23	Latent class growth analysis	Stable-low	83%	-
				Decreasing	7%	-
				Increasing	10%	Had poorer subjective health status than women in stable low and decreasing groups.

uthor	Sample	Assessment	Statistical methodology	Trajectories	%	Maternal predictors
		months, and 24 months postpartum				
Christensen al., 2011)	215 low-income Hispanic immigrant women in the USA	Depressive symptoms were assessed using BDI-II At two time points in pregnancy (mean=18 and 28 weeks' gestation) and three follow-ups at 6 weeks, 4 months, and 12 months postpartum.	Growth mixture modeling	Pregnancy high Postpartum high Perinatal low	10% 10% 80%	- - Unintended pregnancy was marginally significantly associated with an increase in th risk of the postpartum high pattern.
amos-arcuse et . 2010	181 urban, Low-income, first-time, African-American adolescent mothers	Depressive symptoms were assessed using BDI shortly after delivery, and at 6 months, and 24 months after delivery	Semi-parametric group-based modeling strategy	Low Medium High	41% 45% 14%	- Had lower parenting satisfaction than women in the low group. Had lower self-esteem, more likely to experience negative life events, and had lower parenting satisfaction than women in the low and medium groups.
Bayrampour al., 2016)	1445 women from Alberta, Canada	Depressive symptoms were assessed using EPDS and anxiety symptoms were assessed using The State-Trait Anxiety Inventory (STAI) at second trimester, third trimester, at 4 months, and 12	Group-based modelling	Depression: Minimal Mild Postpartum	26% 51% 10%	Had lower income, more education, were more likely to b born in Canada, and were less likely to have a history of menta illness, history of abuse or neglect, low social support, high stress, low perceived physical health, unplanned pregnancy, an infertility history than the reference. Reference. Were more likely to have a history of mental illness, history

uthor	Sample	Assessment	Statistical methodology	Trajectories	%	Maternal predictors
		months after delivery				of abuse or neglect, low social support, high stress, low perceived physical health, and preterm birth than the reference group.
				Antepartum	10%	Had higher income, and were more likely to have a history of mental illness, history of abuse or neglect, low social support, high stress, low perceived physical health, unplanned pregnancy, and infertility history than the reference group.
				Chronic	2%	Were younger, had higher income, and were more likely to be single, and to have a history of mental illness, history of abuse or neglect, low social support, high stress, low perceived physical health, unplanned pregnancy, and infertility history than the reference group.
				Anxiety groups:		
				Minimal	54%	Reference.
				Mild	33%	Had higher income, were more likely to be born out of Canada, and more likely to have a history of mental illness, history of abuse or neglect, low social support, high stress, low perceived physical health, unplanned pregnancy, and infertility history than the reference group.
				Postpartum	5%	Were younger, had higher income, were more likely to be single, and more likely to have a history of mental illness, history of abuse or neglect, low social

uthor	Sample	Assessment	Statistical methodology	Trajectories	%	Maternal predictors
						support, high stress, low perceived physical health, unplanned pregnancy, and preterm birth than the reference group.
				Antepartum	7%	Were younger, had higher income, were more likely to be single, more likely to be born ou of Canada, and more likely to have a history of mental illness, history of abuse or neglect, low social support, high stress, low perceived physical health, unplanned pregnancy, infertility history, emergency CS delivery, and preterm birth than the reference group.
				Chronic	2%	Were more likely to have a history of mental illness, history of abuse or neglect, low social support, high stress, low perceived physical health, and unplanned pregnancy than the reference group.
Don et al., 014)	208 first-time parents (104 Couples) from a low-risk population in the USA.	Anxiety symptoms were assessed using the scl-90r anxiety subscale at third trimester of pregnancy, and at 1 month, 4 months, and 9 months postpartum	Latent class growth analysis	Moderate-stable	11%	Reference.
				Low-declining	89%	Had fewer symptoms of depression, greater expected parenting efficacy, and greater relationship satisfaction in the prenatal period than the referenc group.
Mora et al., 009)	1,735 low-income, multiethnic, inner-city women	Depressive symptoms were assessed using the center for epidemiologic	Growth mixture modeling	Never	71%	Reference.
				Antepartum	6%	Less likely to be born out of the US, and to be Hispanic, more likely to rate their emotional

uthor	Sample	Assessment	Statistical methodology	Trajectories	%	Maternal predictors
	From the USA	Studies depression (CES-D) scale at pregnancy and at 3, 11, and 25 months postpartum				health as poor/fair, more likely t have recent alcohol use, and more likely to be anxious and to have a high level of stress compared to the reference group
				Postpartum	9%	Had lower educational level, higher parity, were less likely to be born out of the us, and to be Hispanic, more likely to rate their emotional health as poor/fair or with a comorbid condition, and more likely to have a high or a moderate level of stress compared to the reference group.
				Late	7%	Had lower educational level, were less likely to rate their physical health as very good and were more likely to have a high or a moderate level of stress compared to the reference group
				Chronic	7%	Had higher parity, were less likely to be black non-Hispanic, more likely to rate their emotional health as poor/fair, an more likely to be anxious and to have a high or a moderate level of stress compared to the reference group.

Appendix B

Questionnaire used to collect data from participants at baseline, Feeling in Pregnancy and Motherhood Study.

PRESENT PREGNANCY

How would you rate your overall health today? ❑Excellent ❑Very Good ❑Good ❑Fair ❑Poor

Date of first pregnancy check-up_____ Who did you see? ❑Doctor_____

What birth control did you use? ❑none ❑condom ❑BCP ❑Mirena/IUD ❑Depoprovera other_____

Did you plan this pregnancy? ❑ Yes ❑ No ❑ sort of

Do you plan to keep the baby? ❑ Yes ❑ No ❑ unsure

How do you feel about the pregnancy? ❑happy ❑scared ❑overwhelmed ❑ not happy ❑ other____

How does your family feel about the pregnancy? ❑happy ❑unsure ❑overwhelmed ❑not happy ❑ __

In the two weeks:
Have you felt down, depressed or hopeless?
❑not at all ❑ several days ❑ more than ½ the days ❑nearly every day

Have you felt little interest or pleasure in doing things?
❑not at all ❑ several days ❑ more than ½ the days ❑nearly every day

Do you plan to breastfeed? ❑Yes ❑No ❑Undecided

Are you interested in Prenatal Classes? ❑Yes ❑No ❑Undecided

CURRENT PREGNANCY-please check those that apply		
❑ severe nausea/vomiting ❑ spotting/bleeding ❑ cramps ❑ headaches ❑ multiple pregnancy ❑ placenta previa	❑ incompetent cervix ❑ premature labour ❑ Hypertension (high blood pressure)/swelling ❑ Urinary Tract Infection ❑ vaginal infection ❑ StrepB infection	❑ anemia ❑ Rh factor ❑ Diabetes ❑ dental problems ❑ other

Medication	**Reason**	**Amount**	**Frequency**

MARITAL STATUS Are you? ❑single ❑ CL ❑married ❑divorced/separated ❑widowed

CURRENT RELATIONSHIP WITH BABY'S FATHER? ❑Yes ❑No

HOW SATISFIED ARE YOU WITH THE RELATIONSHIP? ❑ very ❑ somewhat ❑ not satisfied

EDUCATION: What grade did you finish? ☐ Grade 8 or less ☐ Grade 9 – 11 ☐ Grade 12 ☐ Some post-secondary ☐ Post-secondary ☐ Some University ☐ University

ETHNIC BACKGROUND
Are you? ☐ Caucasian ☐ Treaty –Status ☐ Non-Status ☐ Métis ☐ Other

PAST BIRTHS/ PREGNANCIES: G_____ P _____ T_____ P_____ A _____L_____

NAME	DOB	M F	Birth Wt	Gest	Complications/Comments	Anomalies or problems with child	Breastfed	Lives with

G=all pregnancies; **P**=20 weeks on; **T**=Term; **P**=Preterm <37weeks; **A**=miscarriage<20wks/abortions; **L**=living

HEALTH HISTORY-check which things you have experienced problems with

❑ severe nausea/vomiting	☐ HIV	☐ thyroid
❑ spotting/bleeding	☐ Strep B Infection	☐ heart disease
❑ headaches	☐ anemia	☐ allergies

❑ Urinary Tract Infection	☐ Rh factor	☐ surgeries
☐ vaginal infection	☐ diabetes	☐ other
☐ Sexually Transmitted Infections	☐ seizures	☐ other
☐ Hepatitis		

HOUSING Do you? ☐ own ☐ rent ☐ parents ☐ room & board ☐ YWCA ☐ other
# of adults in household_____ # of children under 18_____

Is it Adequate/suitable? ☐ yes ☐ no ☐ unknown Plan to move: ☐ yes ☐ no when?
_____

EMPLOYMENT Do you work outside the home? ❑ Yes ❑ No
If yes, What is your occupation?_____ how many hours/week do you work?_____

FINANCES Do you have any financial concerns: ❑Yes ❑No
Are you getting? ❑DCRE/social services ❑ Employment Supplement ❑ Band funding ❑ Student loan ❑ PTA
❑ parents ❑ partner ❑_____ _____

In the past 12 months, did you or anyone else in your house.
Not have enough food to eat? ❑ Yes ❑ No
Worry that there would not be enough to eat because of a lack of money? ❑ Yes ❑ No

Do you have a history of PMS? ❑Yes❑No When did it start? ____age ❑before or ❑after pregnancies
Treated ❑Yes❑No Medication ❑Yes ❑No

Do you have a history of depression? ❑Yes ❑No when?
Treated ❑Yes ❑No Medication ❑Yes ❑No

Did you have depression in previous pregnancy? ❑ Yes ❑ No when?
Treated ❑Yes❑No Medication ❑Yes ❑No

Have you had postpartum depression? ❑Yes ❑No when?
Treated ❑Yes ❑No Medication ❑Yes ❑No

Do your moods go up and down? ❑not at all ❑ several days ❑ more than ½ the days ❑nearly every day

Do you have mood swings that occur for no reason? ❑not at all ❑ several days ❑ more than ½ the days ❑nearly every day

Now some questions about your family…
Is your mother alive? ❑Yes ❑No If no, how old were you when she died? _____

Did your mother or any of your sisters have depression before or after giving birth? ❑unknown
Mother ❑ Yes ❑ No sister: 1 ❑ Yes ❑ No 2.❑ Yes ❑ No 3.❑ Yes ❑ No

What things are causing you the most stress right now? ❑nothing right now ***if yes what?***
❑being pregnant ❑ partner/relationship ❑not enough money ❑children ❑family
❑where I live ❑ health of my baby ❑birth of my baby ❑health ❑work
❑school ❑ Other _____ _____ _____

Do you have someone to turn to for emotional support? ❑Yes ❑No ***If yes, who gives you support?***
❑ Partner ❑ Mother *(don't ask if mother not alive)* ❑ Friend ❑ Female relatives ❑ Other_____

Who of these gives you the most support? _____
Can you count on that person to care about you no matter what? Yes ❑ No ❑

During the past year, from yesterday to one year ago yesterday…
Have you had a drink alcoholic beverages (beer, wine, coolers) at all? ❑ Yes ❑ No ***If yes,***

Did you drink alcohol?
Less than once a month ❑ once a month ❑ 2 to 3 times/month ❑
once a week ❑ 2 to 3 times a week ❑ 4-6 times a week❑ every day ❑

How often did you have more than 5 drinks at one time?
Never ❑ less than once a month ❑ once a month ❑
2 to 3 times/month ❑ once a week ❑ more than once a week❑
During the past week, did you drink alcohol? ❑ Yes ❑ No

The next three questions relate to any type of abuse you may be experiencing.
Has anyone ever hit, slap, restrained, punch, pinch, kick, beat you? ❑ Yes ❑ No
Has anyone ever yell, belittle, berate, blame, neglect? ❑ Yes ❑ No
Has anyone touched you against your will, raped you? ❑ Yes ❑ No

Have you had counseling in the past? ❑ Yes ❑ No
If yes, what for? ❑ depression ❑ relationship ❑ addiction ❑ eating disorder ❑ abuse
❑other
_____

Are you seeing a counselor right now? ❑ Yes ❑ No
If yes, why? ❑ depression ❑ relationship ❑ addiction ❑ eating disorder ❑ abuse

Do you have any legal problems? ❑ Yes ❑ No

Date: _____ Interviewer: _____person/telephone

Please underline the answer, which comes closest to how you have felt in the <u>past 7 days</u>, not just how you feel today:

I have felt happy:

Yes, most of the time
<u>Yes, some of the time</u>
No, not very often
No, not at all

In the past 7 days:

1. I have been able to laugh and see the funny side of things:
   As much as I always could
   Not quite so much now
   Definitely not so much now
   Not at all

2. I have looked forward with enjoyment to things:
   As much as I ever did
   Rather less than I used to
   Definitely less than I used to
   Hardly at all

3. I have blamed myself unnecessarily when things went wrong:
   Yes, most of the time
   Yes, some of the time
   Not very often
   No, never

4. I have been anxious or worried for no good reason:
   No, not at all
   Hardly ever
   Yes, sometimes
   Yes, very often

5. I have felt scared or panicky for no very good reason:
   Yes, quite a lot
   Yes, sometimes
   No, not much
   No, not at all

6. Things have been getting on top of me:
   Yes, most of the time I haven't been able to cope at all
   Yes, sometimes I haven't been coping as well as usual
   No, most of the time I have coped quite well
   No, I have been coping as well as ever

7. I have been so unhappy that I have had difficulty sleeping:
   Yes, most of the time
   Yes, sometimes
   Not very often
   No, not at all

8. I have felt sad or miserable:
   Yes, most of the time
   Yes, quite often
   Not very often
   No, not at all

9. I have been so unhappy that I have been crying:
   Yes, most of the time
   Yes, quite often
   Only occasionally
   No, never

10. The thought of harming myself has occurred to me:
   Yes, quite often
   Sometimes
   Hardly ever
   Never

Circle the response that fits closest to your experience during the <u>past 7 days</u>.

1. How often have you felt like being sick (nauseated) in the past week?

All the time	More than once a day	Daily	3-6 days during the week	Occasionally	Not at all

2. How often have you retched/dry heaved (but without actually being sick) in the past week?

All the time	More than once a day	Daily	3-6 days during the week	Occasionally	Not at all

3. How often have you been physically sick (vomited) during the past week?

All the time	More than once a day	Daily	3-6 days during the week	Occasionally	Not at all

Please circle a number for each one to show how much of a worry it is to you now, from 1 if it is not a worry to 5 if it is something that you are extremely worried about:

Major worry	**Not a worry**				
Your housing	1	2	3	4	5
Money problems	1	2	3	4	5
Problems with the law	1	2	3	4	5
Your relationship with your partner/husband	1	2	3	4	5
Your relationship with your family and friends	1	2	3	4	5
Your own health	1	2	3	4	5
The health of someone close to you	1	2	3	4	5
Employment problems	1	2	3	4	5
The possibility of something being wrong with baby	1	2	3	4	5
Going to hospital	1	2	3	4	5
Internal examinations	1	2	3	4	5
Giving birth	1	2	3	4	5
Coping with the new baby	1	2	3	4	5
Giving up work (if applicable)	1	2	3	4	5
Whether your partner will be with you for the birth	1	2	3	4	5
Possibility of miscarriage	1	2	3	4	5

If there is anything else that is worrying you or you would like to say anything more about any of the above,
please use this space to tell us about it:

How many drinks can you hold? ____

Have close friends or relatives worried or complained about your drinking in the last year? Yes❑ No❑

Do you sometimes take a drink in the morning when you first get up? Yes❑ No❑

Has a friend or family member ever told you about things you said or did while you were drinking that you could not remember?? Yes❑ No❑

Do you sometimes feel the need to cut down on your drinking? Yes❑ No❑

In the last month…

How much do you exercise? (walking for 20 minutes, swimming etc.)

Every day ❑
2-3 times a week ❑
Occasionally ❑
Never ❑

How much do you smoke? (√ one)

More than a pack/day ❑
5-20/day ❑
Less than 5 a day ❑
Quit since pregnant ❑
Quit before pregnant ❑
I never smoked ❑

Does anyone else smoke inside your home? Yes❑ No❑

How often did you drink beer or other alcohol? (√ all that apply)

Occasional drink or 2 ❑
1-2 drinks a day ❑
5+ drinks at one time ❑
Quit since pregnant ❑
Quit before pregnant ❑
I never drank alcohol ❑

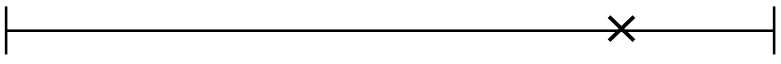
How often did you use drugs such as marijuana, crystal meth. cocaine? (√ one)

Regular (every day) ❑
Occasionally ❑
Quit since pregnancy ❑
Quit before pregnant ❑
I never use such drugs❑

Your family income: (√ <u>one only</u>)

Social/Band Assistance: ❑
Less than $20,000./yr ❑
$20-40,000./yr ❑
$40-60,000./yr ❑
More than $60,000./yr❑

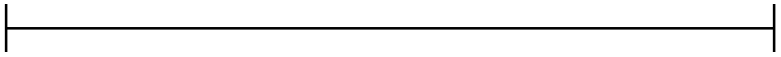
I have frequent hiccups. *(Place an 'X' on the line as below)*



Not at all true Yes, very much true

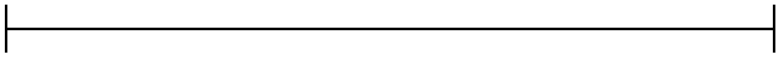
In the last <u>month</u> how much have the following statements been true for you?

1. **I have frequent ups and downs of moods.**



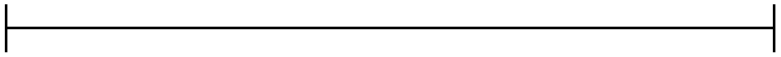
Not at all true Yes, very much true

2. **I have mood swings that occur for no reason.**



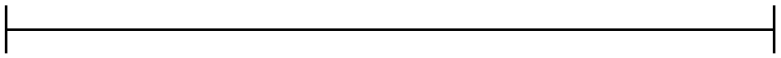
Not at all true Yes, very much true

3. **Other people complain about my mood swings.**



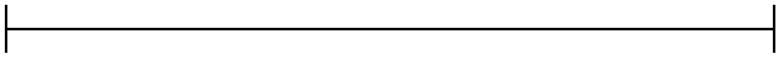
Not at all true Yes, very much true

4. **Because of my moods, I have trouble following through with my plans.**



Not at all true Yes, very much true

5. **I don't like to make commitments because my moods might change.**



Not at all true Yes, very much true

Your postal code_____

Please circle the number to indicate whether you strongly agree, agree, disagree or strongly disagree to the following statements about your community	Strongly Disagree 1	Disagree 2	Agree 3	Strongly Agree 4
This is a close knit neighborhood	1	2	3	4
People in this neighborhood can be trusted	1	2	3	4
People around here are willing to help their neighbors	1	2	3	4
People in this neighborhood do not share the same values	1	2	3	4

People in this neighborhood generally do not get along with each other	1	2	3	4
It is safe to walk alone in this neighborhood after dark	1	2	3	4
It is safe for children to play outside during the day	1	2	3	4
There are good parks, playgrounds and play spaces in this neighborhood	1	2	3	4

How do you feel about your neighborhood as a place to bring up child? Is it…

Excellent ❑ Good ❑ Average ❑ Poor❑ Very poor❑